Smithsonian

FEBRUARY 2000

The Stone Carvers' Art

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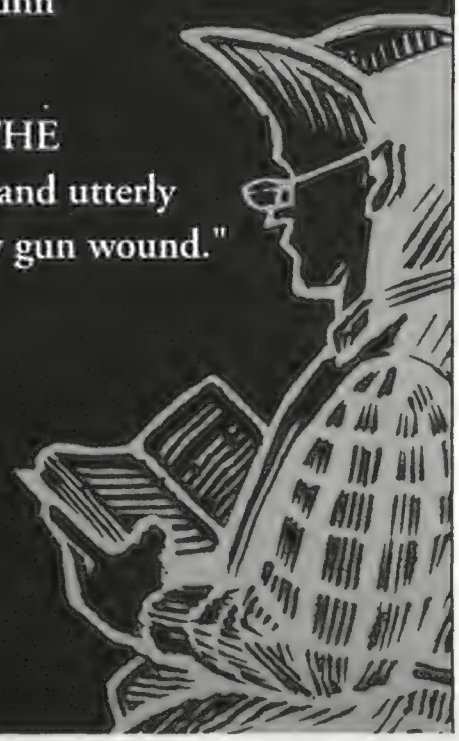

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A Smithsonian for this Century

A NOTE FROM THE SECRETARY

IN THE FOUR MONTHS BETWEEN MY APPOINTMENT AS Secretary-elect of the Smithsonian in 1999 and the moment when I formally took on the daily responsibilities of the job last month, I sought to learn as much as I could about the Institution's history, collections and people—the people who shaped its first century and a half and those dedicated today to seeing it flourish in a new century. The more I discovered about this marvelous national treasure, the more I wanted to share the knowledge. Like some latter-day ancient mariner needing to tell my tale, I would buttonhole friends and, after the obligatory "Did you know . . . ," share a portion of the bottomless store of statistics that measure the scale and reach of the Smithsonian.

As I cornered those patient friends, I found that all of them recognized the name "Smithsonian Institution" but that few had any idea of the breadth and depth of our activities, of how they emerged over time, or of how they relate to one another as distinct components of a single organization. I became convinced that we need to articulate an overarching vision for the Smithsonian that will convey clearly what we are, what we do and why we do it, and where our mission will take us in the years ahead.

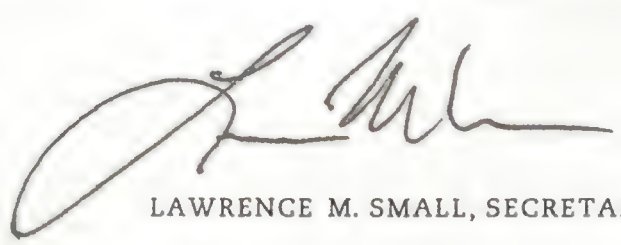
The Smithsonian's time-honored mission, the "increase and diffusion of knowledge," dates back to its origins. But in spite of the words' great traditional appeal, I wonder whether the goal they define has not become too vague and amorphous in a world where there are thousands of institutions and undertakings that may legitimately lay claim to that same purpose. "Increase and diffusion" grabbed headlines in the 19th century. I want to find their vital and compelling equivalent for the 21st century. In fact, today's Smithsonian, the complexity of which no one could have foreseen 154 years ago when its founders imagined that a single building would contain the enterprise, may require several mission statements and several associated sets of goals and plans. Let me explain.

The Smithsonian is the nation's principal repository of objects that have shaped our knowledge of the cultural and scientific histories of America and the world. The great public mission of the Smithsonian is to use our resources to create experiences that will educate, excite, entertain and inspire Americans (and visitors from abroad) more constructively than any other educational and cultural institution in the United States. Our approach is holistic—in the museums, in the traveling exhibitions that extend the museums, in our festivals and talks and performances, in print, on-screen and on-line—and it has no equal.

The collections-focused activities of the Smithsonian—the museum experience in all its imaginative variety—are familiar to Americans. But the Smithsonian is also a center of first-class scientific activity in a number of highly specialized areas—at the Smithsonian Astrophysical Observatory and the Smithsonian Tropical Research Institute, for example—work that, unfortunately, is not at all familiar to the public. I shall say much in future columns about our scientific mission and how it should serve America's educational, government and business institutions.

For now, I want to reaffirm our broad public mission, which we can accomplish only if we recognize certain defining new realities of contemporary American life. The most dynamic population growth in the nation today is in the South and West, and we must reach those new audiences. More important, by the middle of the 21st century, nearly half of U.S. residents will belong to groups that today constitute the minority. We must make certain that the Smithsonian speaks to them. In fact, we must learn to speak to the new generations of *all* backgrounds. In this embracing of new audiences, technology can be an ally, and we should capitalize upon the promises of the Internet, of instant communication and unlimited access, and of increasingly refined displays of digital sound and images.

But there is something to be said for the old-fashioned approach as well. For us that means getting the actual treasures of the Institution out of our "attics" and into locations across America. Our traveling exhibitions are one way of doing that, and we need to increase their number and frequency. We are also establishing new and, I hope, stable and enduring relationships by affiliating with other museums and depositing with them portions of our collections. In sharing our resources, so that the objects can be seen and enjoyed by new audiences in communities far from Washington, we are determined to make the Smithsonian of the 21st century more fully and precisely what the Institution exists to be—America's museum.



LAWRENCE M. SMALL, SECRETARY

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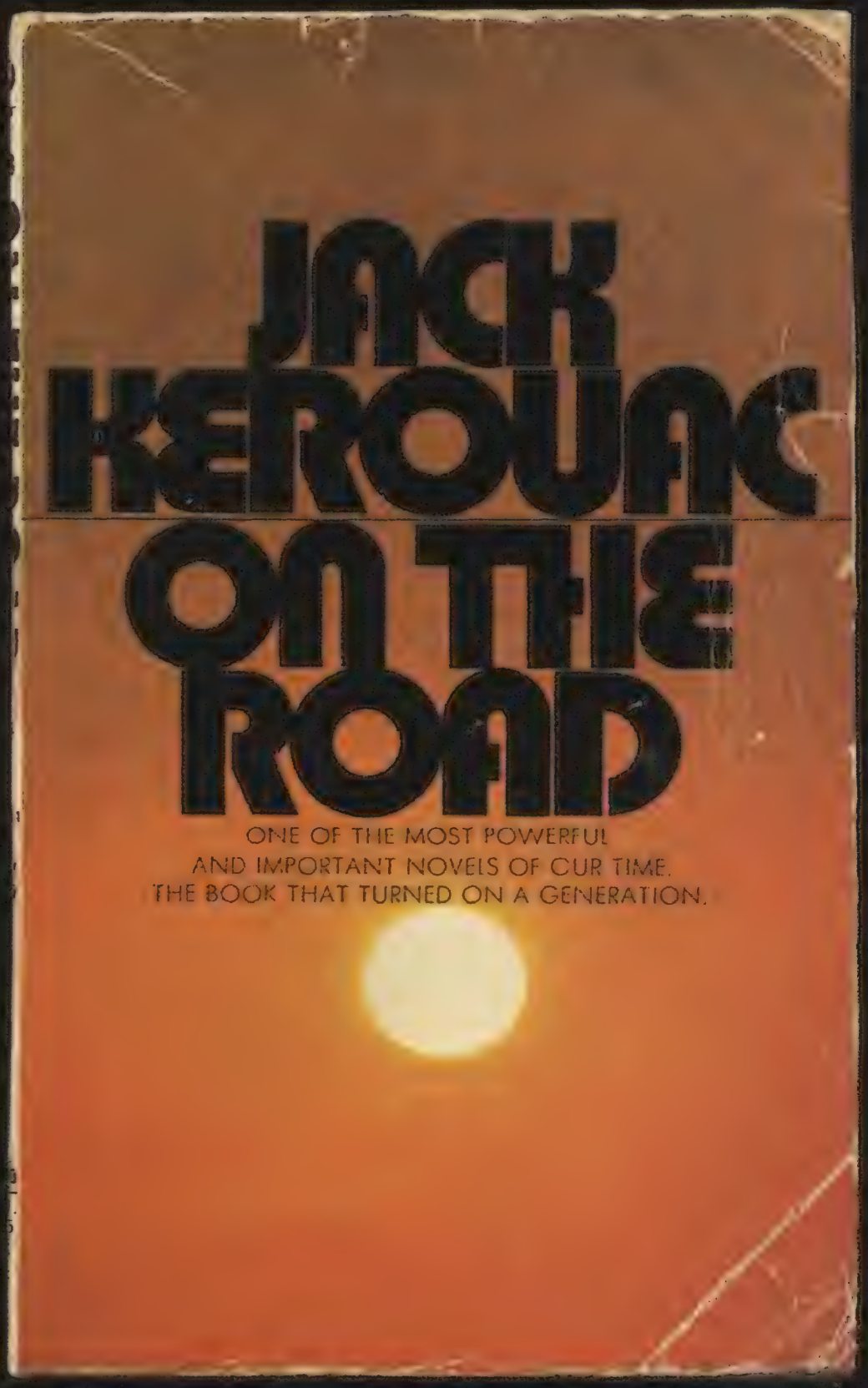

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AROUND THE MALL & BEYOND

AS MICHAEL KERNAN WROTE IN "Animal Old Folks," in the December 1999 issue, blueberry muffins were one of Hsing Hsing's favorite foods toward the end of his life. They were also the best way to hide the taste of his arthritis medicine. Hsing Hsing was a one-of-a-kind patient, but in some respects his case was not unique. All of our geriatric zoo animals face age-related problems that we cannot always fix. As Hsing aged, he developed a variety of problems—arthritis, testicular cancer, kidney failure—that could be managed but not necessarily solved. The goal of veterinarians is to maintain quality of life for these patients.

We learned a lot from Hsing. He responded very well to medical management during his twilight years, bouncing back from his April 1997 testicular surgery, and even rolling and playing again after we started him on carprofen for his arthritis. For more than two years, Hsing remained in excellent health for a geriatric giant panda. His kidneys began to fail in May 1999, and we had to anesthetize him repeatedly to give him intravenous fluids. We were successful in stabilizing his kidney function, but he was severely anemic, a secondary effect of renal failure. His day-to-day prognosis was very poor. Our only option for treating the anemia was to use the human recombinant hormone erythropoietin (EPO), a red blood cell stimulant that had been used successfully in people, dogs and cats, but not in the giant panda. The EPO worked remarkably well for Hsing, and he surprised all of us by regaining his appetite and strength for another six months, despite severe progressive kidney failure.

When Hsing suddenly began to decline during the last week in November, gradually losing his appetite and strength, we gave him extra doses of carprofen and erythropoietin. Although he responded and ate better for a few more days, the drugs' effects were short-lived.

The decision to euthanize Hsing was a collective one made by curators, keepers, veterinarians and zoo officials. It was easy because we knew

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it was time. It was hard because we knew how much we would miss this great bear.

Lucy H. Spelman, DVM
Head, Department of Animal Health
Smithsonian National Zoological Park
Washington, D.C.

ELK

READERS OF SCOTT WEIDENSAUL'S article "The Return of the Elk" may be interested to know that the wildlife biologists working on the relocation of elk from Utah to Kentucky have managed to bring down the mortality rate significantly. Of the 141 elk relocated to Kentucky in 1999, there were only three deaths related to the move, about as close to zero percent as you can get, as Lou Cornicelli of Utah's Division of Wildlife Resources recently said.

Louise Ladd
Lexington, Kentucky

THE ELKS LODGE THAT IS LOCATED in Gaylord, Michigan, overlooks an elk refuge. It may be the only Elks Lodge in the United States where members and visitors can view and feed elk.

George Craven
Belleville, Michigan

According to Hermann Schmitz, the treasurer of the Gaylord B.P.O. Elks Lodge #2544, the Elks garnered the requisite permits to put an elk bull, cow and calf on the nearly 40 fenced acres behind their building about ten years ago. Today the herd numbers 30. Ed.

TWO THOUGHTS CAME TO MIND AFter reading your article. I was reminded of the large herds of elk I saw roaming the national park areas of the Canadian Rockies last summer. The majestic animals took people in stride, as if "two-leggeds" cohabiting their homeland was perfectly natural, as were the bridges that the people had built over the highways so the animals could safely pass.

The second thought concerned the year I spent teaching English to students in rural eastern Kentucky. In the writing assignments, the most frequent topic for males other than basketball was hunting: squirrels for freshmen; raccoons for sophomores; deer for juniors. I pray that the elk herds remain sufficiently protected and elusive so they might survive what seemed to me to be the adolescent rite of passage in this state.

Jennifer Little
Louisville, Kentucky

THE MEASURE OF TIME

THE ARTICLE BY PER OLA AND EMILY d'Aulaire, "Taking the Measure of Time," brought to mind an incident that happened to my family more than 60 years ago. My sister was 8 and I was 6 when we escaped with my parents from the Nazis, traveling from Belgium through Portugal. At U.S. Customs in New York, a clerk noticed a Snow White windup clock in our luggage. Snow White had a bluebird on her index finger that rocked back and forth with each ticktock. The Seven Dwarfs were pictured around the clock's numbers. When the clerk took it to another clerk, my sister and I howled in pain because our mother had suddenly pinched our bottoms. The clerk turned to us, and my mother pleaded, "Please don't take away their little clock. They love it so much." He angrily tossed the Snow White clock back into our luggage.

Only our parents knew that unpolished diamonds were hidden in the works of the clock.

Sylvan E. Bluestein
Baltimore, Maryland

THE CLOCK ON PAGE 60 THAT YOU identified as "an American woodengear clock (c.1815)" is an early 20th-century punch clock that was made by the International Time Recording Company of New York (now IBM Corporation). The clock to its right has wooden gears. I have been fasci-

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TIDY CATS SCOOP
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TIDY CATS SCOOP

nated with clocks and watches all my life and own examples of both of these timepieces.

Robert Waltz
Canton, Ohio

Mr. Waltz is correct. The clock we showed (above) dates from about 1912, and served a factory in the garment district of New York City. The concentric circles had numbers on them, and each worker was assigned a specific number. Upon arrival at work, the employee rotated the circle until the number met the radial bar. The worker then punched the bar, or "punched in," which recorded the time and the worker's number on a paper roll inside the box.

The Connecticut box clock is the wooden-gear clock. Ed.

ON PAGE 61, YOU SHOWED PICTURES of Helen Keller's pocket watch, but I would like to know more about it.

Malcolm Whatley
Burlington, Vermont

In the late 19th century, a watchmaking firm in Geneva, Switzerland, made the rare type of watch, called a *montre à tact* or "touch watch." It was designed for use by anyone who needed to tell time in the dark—or on the sly, such as a diplomat who wouldn't want to be caught "watching the clock." According to research by Silvio Bedini, historian emeritus of the Smithsonian Institution, John Hitz, formerly the Swiss Consul General to the United States and then superintendent of Alexander Graham Bell's Volta Laboratory, met Helen Keller in 1894 and gave her the watch on her 14th birthday (a former German diplomat had given it to Hitz). Keller kept the watch until her death in 1968. It was later donated to the National Museum of American History. Ed.

THE SPEED OF LIGHT IN A VACUUM IS rounded off to 186,282 miles per second, not 186,347 miles per second, as you stated.

John Abbott
Silver Spring, Maryland

THE ARTICLE BY THE D'AULAIRES IS another of the many exceedingly well-written contributions they have made to SMITHSONIAN over the years.

I have one rather important quibble though: the origin of the term "knot" that the writers give is historical enough, but the knot's modern definition is more direct. A nautical mile, universally used by navigators whether their other distance measures are in metric or "English" units, is one minute of arc on the earth's surface (or 1/60th of a degree of longitude at the equator, or 1/60th of a degree of latitude anywhere). A knot is defined as one nautical mile per hour. Only when converted to our peculiar English system is it 1.15 (statute) miles per hour. Both aviators and professional sailors in the United States and around the world do not convert; sticking to knots means that units of speed, distance and location on the globe are all compatible.

Bill Withuhn
Curator of Transportation
National Museum of American History
Washington, D.C.

THE NATIONAL INSTITUTE OF STANdards and Technology (NIST) is, as you reported, working on an advanced laser-cooled cesium atomic clock, and a model will be placed aboard the International Space Station. The clock will not function "independently of gravity," as you wrote, but in apparent microgravity. Orbiting satellites are held in orbit by the earth's gravity, which for the typical altitudes of about 300 miles is better than 85 percent of the strength at the surface of the earth. The apparent "weightlessness" is observed because the satellite and all its contents are falling together toward the center of the earth.

Robert P. Bauman
Professor Emeritus of Physics
University of Alabama-Birmingham
Birmingham, Alabama

While Professor Bauman is correct that matter anywhere in this universe is affected by gravity, anything can free itself from the tug of gravity by falling freely, according to the NIST. Just as the astronauts will float around on the space station, the atoms in the clock will float around the same way whether they are in free fall in a strong gravitational field, or in a tiny interstellar field. In this sense, they behave independently of gravity. These floating atoms allow the construction of a much better laser-cooled cesium atomic clock. The frequency of the clock, however, is sensitive to its position in the gravity well, through the gravitational redshift of general relativity. This shift is quite small but is an important aspect of the science of time and the practical issues of timekeeping, so it is of great interest to scientists. Ed.

BURKE'S PEERAGE & BARONETAGE

KUDOS TO RICHARD CONNIFF FOR HIS article "Class Dismissed." I cannot remember ever having laughed harder at a magazine article in my entire, noble life. Talk is cheap (though titles are not), but as a longtime historian, I found it refreshing to be reminded that the likes of Baroness Strange and Lord Bath are human—not just a string of hyphenated surnames in the pages of *Burke's Peerage*.

Dylan Thos. Good
Lincoln City, Oregon

THOUGH I ENJOYED YOUR ARTICLE, I found the entire topic quite disturbing. That people would actually want

DANE PENLAND, SI

to be classified among the "peerage" boggles my mind. I cannot comprehend the ubiquitous fascination with royalty and nobility.

Jorian P. Schutz
Boulder, Colorado

THOMAS EDISON

I READ THE ARTICLE "MR. EDISON Takes a Holiday" by Richard and Joyce Wolkomir with interest. Please tell 94-year-old Bob Halgrim, who said, "I'm just about the only person left who actually worked for Mr. Edison," that another worker is still alive: my husband. Albert (Abbey) Leitch was born in 1898, and two years later, his family moved to West Orange, New Jersey, a few blocks from the Edison factory. When Abbey was 12, he applied for a job at the factory and was hired as Mr. Edison's office boy.

Helen K. Leitch
Jupiter, Florida

BOYS CHOIR OF HARLEM

HOW CAN I MAKE A CONTRIBUTION to the Boys Choir of Harlem, which you featured in "The Boys Choir of Harlem Sings a Song of Hope"?

Hal Woods
Chicago, Illinois

Please send donations to the Choir Academy of Harlem, Boys Choir of Harlem, 2005 Madison Avenue, New York, New York 10035. Ed.

WRITE TO SMITHSONIAN

Letters for consideration in this column must include your daytime telephone number, full name and postal address. Transmit mail to LettersEd@simag.si.edu or send it to Smithsonian Letters Editor, P.O. Box 44400, Washington, D.C. 20026-4400. Letters may be edited for clarity and length.

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POINTS OF INTEREST

The End of the Road

IN IDAHO'S CLEARWATER NATIONAL FOREST, OLD LOGGING ROADS THAT RUIN STREAMS ARE GETTING THE AXE

BY T. H. WATKINS

I FOUND IT DIFFICULT NOT TO COMPARE THE THING IN front of me to some kind of unclassifiable dinosaur clawing its way through the landscape. But it was just a track hoe, a 50,000-pound excavator with huge treads and a 50-foot arm from which a big bucket depended like an enormous fist. The operator sat in the cab and yanked levers as the critter growled down the ancient logging road, its bucket swinging from side to side to knock over trees like Godzilla slapping down office buildings.

Anne Connor grinned at my openmouthed awe. "On a stretch like this," she said, "he can clear a quarter-mile an hour." That seemed to please her. We were on the side of a mountain in Idaho's Clearwater National Forest. With me were Connor, a civil engineer with the U.S. Forest Service, Ira Jones, director of watershed programs for the Nez Perce tribe, and Emmit Taylor, Jr., a watershed project leader for the tribe. With impetus and funding from the Forest Service and the Bonneville Power Authority, these three were joining forces to turn history on its head.

They were killing roads—though "obliteration" and "decommissioning" are the preferred terms. This is not an activity for which Uncle Sam has been noted. Quite the opposite, in fact—a truth that had come through with particular force earlier that day when I drove through portions of the Clearwater. The brow of just about every mountain I saw was scarred by tier upon tier of roads.

It had all been part of the most ambitious logging program in Forest Service history. After World War II the agency, citing the national demand for housing, began to convert much of its 180-million-acre domain into clear-cuts made accessible by roads. By the mid-1990s, there were some 383,000 miles of official forest roads, plus at least another 52,000 miles of "unclassified" roads, many of them created unofficially by fast-moving logging and mining companies, or by recreational ATV drivers.

"Roads have been identified as *the* major impact on the forest environment," a hydrologist at Montana's Kootenai National Forest wrote in 1995. Many of those built during the first frenzied decades of the logging boom were simply

Workers and a track hoe (bottom) restore a stream channel altered by one of the roads that scar mountains in the Clearwater (top).

GLENN OAKLEY (2)

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The immediate effect is to create an area as ugly as a war zone, but recovery is fast.

abandoned. Maintenance budgets were inadequate even to keep stable roads in good condition, and thousands of miles were unstable. Culverts plugged up with debris. Roads sagged. Rainfall washed increasing levels of sediment down mountain slopes, clogging rivers and smothering fisheries. Occasionally, huge chunks of deteriorating roadbeds collapsed, sending an avalanche of mud, rocks and trees crashing into some hapless stream.

By the 1980s, it was clear to many that something had to be done, but for years not much was. Then in 1997, the Forest Service's new chief, Mike Dombeck, asked for an increase of $22 million in his budget to remove 3,500 miles of roads, which Dombeck characterized as only a fraction of those eligible for closure. "It was an excellent start," observes Bethanie Walder, director of the Wildlands Center for Preventing Roads, in Missoula, Montana. "But if you don't address the potential hydrological impacts of every road, no matter how stable it seems, you're just creating time bombs."

Grass and other vegetation flourish on what used to be a fork of the Squaw Creek Road. The fork was "obliterated" in the summer of 1998.

The Clearwater is one of the most thoroughly roaded of all the national forests and, at the same time, the one with perhaps the most vigorous obliteration program. Nature had helped, Anne Connor told me. For years, road obliteration had been low on the Clearwater's budgetary totem pole, but in the mid-1990s rainfall greatly exceeded normal levels. Nearly a thousand landslides resulted, and more than 500 of those fiascoes were road-related.

"I can remember thinking in my early years that if one road failed, the debris would be stopped by the road below," Connor said. "After the floods, I knew that just wasn't true. You get a failure on the top road, and it just slams through the whole series and takes every other road right on down the line."

Connor began an inventory that soon identified nearly 2,000 miles of road-obliteration candidates. Most were old "jammer" roads, primitively engineered tracks that had been hurriedly gouged into the mountains from the 1950s to the '70s for timber harvest. Trees were cut from the slopes below each road, then hauled up by cable for loading onto trucks. Because the cables of that time were short, it took a lot of roads to strip a single slope of its timber. The roads were so closely packed that, in at least one of the worst areas, there were 60 miles of roads in a single square mile, taking up a full third of the total land base.

By the time of my visit, crews had obliterated 225 miles of roads in the Clearwater. A messy business, I learned. First, in order to gain access, you go in with the track hoe and wipe out all the trees on the roadbed, as I had just seen happen—a bad moment for an old tree-hugger like me. "You have to remember," Emmit Taylor told me as some good-looking trees were knocked over by the big machine, "we're talking about a hundred-year recovery plan here. So sometimes you have to sacrifice 30-year-old trees to do the job right."

Once the road has been cleared, the track hoe reverses itself, pulling up dirt and woody debris from the road's downhill, or cliff, side and piling it against the other side. This partially recontoured roadbed is then seeded, and shrubs are transplanted, for revegetation. At every stream crossing, the machine rips up even more of the roadbed and rebuilds the site to mimic a natural watercourse. Rocks, straw bales, downed trees and other vegetation are manipulated into place to help control erosion.

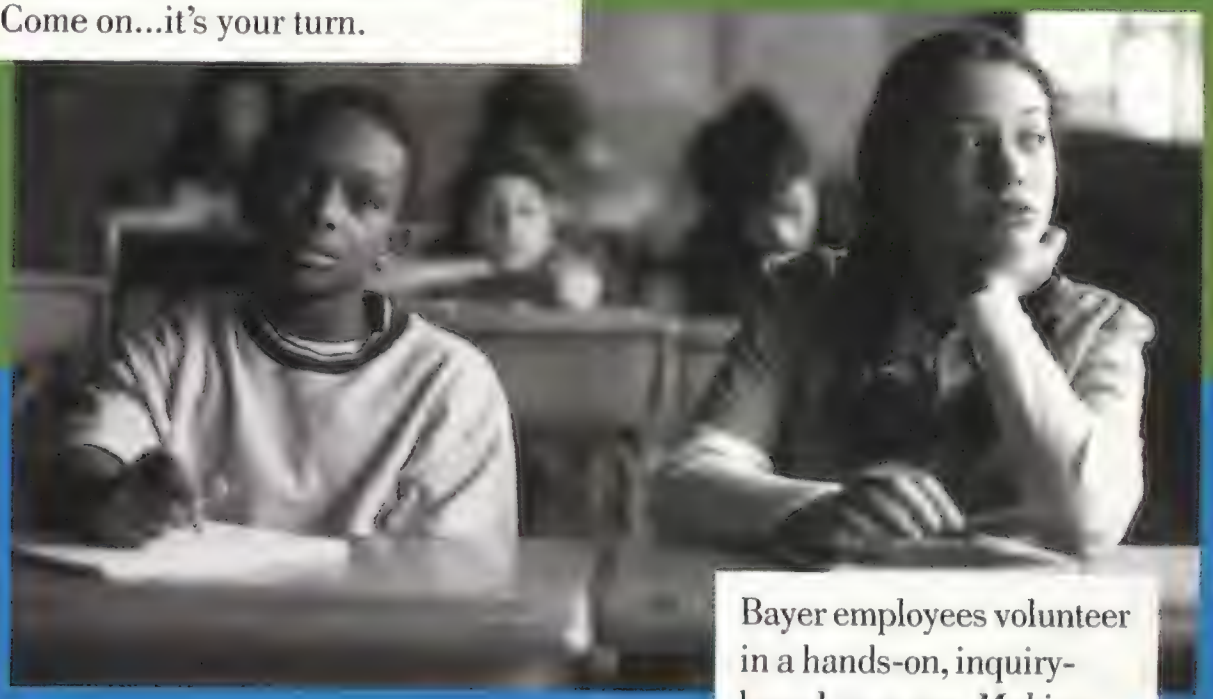
It all happens swiftly and noisily, and if the immediate effect is to create an area as ugly as a war zone, recovery is astonishingly fast. Later that day, Connor and her fellow road-killers showed me one they had obliterated less than a year earlier. I saw hardly a sign that there had ever been a road. Everywhere, grasses abounded, and tiny sprouts of ponderosa pine and white pine poked their heads above the artful rubble.

Emmit Taylor had done much of the work here, and his obvious pleasure in showing off the results put me in mind of something Dombeck said back in 1998, around the time he first proposed a controversial road-building moratorium that now affects millions of acres of forest land. "In fifty years, we will not be remembered for the resources we developed; we will be thanked for those we maintained and restored for future generations."

Thanks, Emmit.

GLENN OAKLEY

YOU'RE ON. Try to get them interested in why lighter things fall as fast as heavier things. And how. Come on...it's your turn.



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THE OBJECT

AT HAND

Last of the Wild Buffalo

LONG DISPLAYED, LONG DISPERSED, THE FAMOUS HORNADAY BISON "FAMILY" IS REUNITED IN A NEW HOME

BY HANNA ROSE SHELL

ONE DAY IN 1957, WORKERS UNDERTAKING A MAJOR, much-needed refurbishment of the Smithsonian's U.S. National Museum discovered a metal box embedded in the base of an antiquated display of American buffalo. Inside was a note dated March 7, 1888, written by naturalist, hunter and conservationist William Temple Hornaday. Chief taxidermist at the National Museum from 1882 to 1890, director at various times of both the Institution's first zoo and the New York Zoological Park, and president of the American Bison Society, Hornaday was one of the best-known naturalists of his time.

The Buffalo Group, created as an exhibit between 1887 and 1888, was among the earliest products of Hornaday's wide and varied career as taxidermist, writer and activist. The note Hornaday had enclosed within the Buffalo Group's case read:

> My Illustrious Successor, Dear Sir:
> Enclosed please find a brief and truthful account of the capture of the specimens which compose this group. The Old Bull, the young cow and the yearling calf were killed by yours truly. When I am dust and ashes I beg you to protect these specimens from deterioration and destruction. . . .
>
> W.T. Hornaday, Chief Taxidermist

During the two decades before Hornaday had written this plea to future generations, sportsmen, ranchers and professional hunters had killed millions of buffalo, or bison, as these mammals of North America and Europe are more correctly called. Perhaps as many as 60 million American bison ultimately became the victims of progress.

Unlike most others of his day, Hornaday was concerned about the imminent extinction of the buffalo. A prolific writer of popular magazine articles and books, and an outspoken public figure, Hornaday was a leading spokesman for the early conservation movement between around 1880 and his death in 1937. A contemporary of the equally impassioned outdoorsman Theodore Roosevelt and a fellow member of the Boone and Crockett Club, Hornaday earned the special admiration of several generations of young boys for his volumes on hunting and natural history.

Concerned that the rapid disappearance of the buffalo would soon make it impossible for the museum to acquire top-quality specimens for posterity, Hornaday and a crew went in the spring and fall of 1886 to eastern Montana where they collected 25 buffalo of both sexes and various ages. From these, Hornaday chose a massive bull, a hefty cow, a smaller cow, a young spike bull, a yearling and a suckling calf for his exhibit. He mounted the six specimens in a 16-by-12-by-10-foot glass-and-mahogany case.

Finally, in March 1888, before an ecstatic public, the National Museum lifted the screen that surrounded the completed Buffalo Group. The *Washington Star* ran an article with the following headline: "A scene from Montana—Six of Mr. Hornaday's Buffaloes form a picturesque group—A bit of the Wild West reproduced at the National Museum—Something novel in the way of taxidermy—Real buffalo-grass, real Montana dirt, and real Buffaloes."

William Hornaday leads Sandy, the bison calf whose antics charmed Smithsonian visitors in the summer of 1886.

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Sandy began to acquire a humped back, more bulk and increasingly unruly tendencies.

The newspaper described the large male as "the huge buffalo bull, the giant of his race . . . the one believed to be the largest specimen of which there is authentic record."

The Buffalo Group quickly achieved acclaim as a symbol of the early conservation movement and as an outstanding example of the new school of taxidermy of the 1880s and 1890s. Scientists as well as laypeople recognized that the group exhibit, with its suggestion of habitat, was innovative both in method and effect. The director of the National Museum, G. Brown Goode, hailed it as a "triumph of the taxidermist's art." And soon after the first public viewing, the president of the rival American Museum of Natural History was already rallying funds to build his own buffalo group in New York City.

During the spring expedition to Montana, one of Hornaday's crew had captured a live male buffalo calf. Hornaday had long been interested in exhibiting live animals at the National Museum and decided to bring the calf back to the Smithsonian, where he was penned up on the lawn of the National Museum, today the Arts and Industries Building. Named Sandy for his yellowish-blond color, the calf remained in his enclosure during the summer months of 1886.

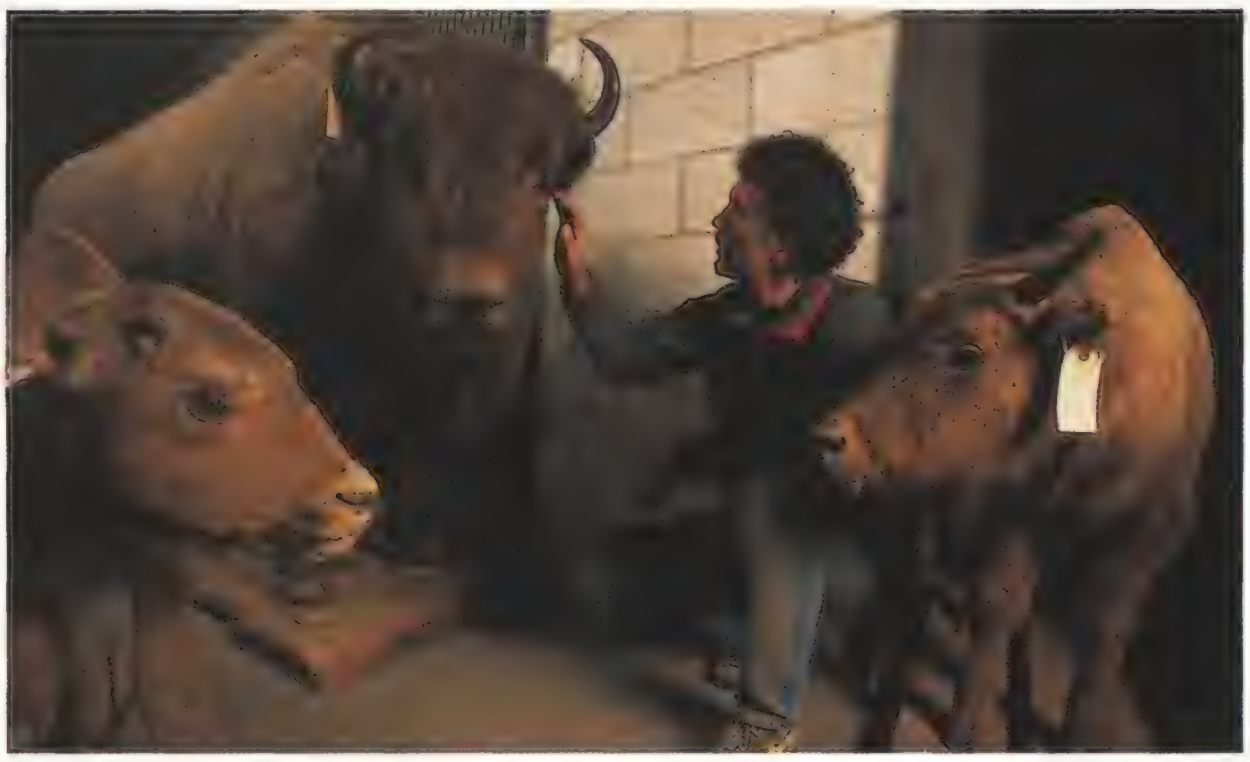
Over the course of a few weeks, however, Sandy began to acquire a humped back, more bulk and increasingly unruly tendencies. Andrew, Sandy's human attendant, had to cope with the fat and fractious animal. In 1887, Hornaday described the violent confrontations between animal captive and human keeper in the *Cosmopolitan* magazine: "Going up to the now quite demure looking calf . . . [Andrew] muttered, 'Confound your hide! You son of a gun, if I wasn't so attached to ye, I'd kick the stuffing out o' ye *right now!*'"

A few days later the calf died, probably from eating too much damp clover. Hornaday eventually decided to incorporate Sandy into the unfinished group, draping his treated hide over a wood-and-clay form.

Before Sandy's untimely death, Smithsonian visitors had enjoyed watching the calf's daily activities through the fence of his pen near the National Museum. Inspired partly by this interest, Hornaday returned to another project, the establishment of the Department of Living Animals at the Smithsonian.

In October 1887, Director Goode implemented Hornaday's proposal on a trial basis, naming Hornaday the department's first curator. Goode and Hornaday justified the department's existence on the grounds that it would afford museum taxidermists an opportunity to observe the habits and positions of the various species as they were in life.

In December 1887, the initial collection of live North American mammals and birds moved into its quarters by the National Museum building. When the mini-menagerie was opened to the public, it was instantly popular with young and old alike. By April 1888, the collection had grown to 172 creatures. Hornaday admitted to the *Washington Star* that he hoped to establish a full-fledged national zoo for the conservation and study of wild animals sacred to the national heritage. He wanted living as well as dead buffalo preserved for posterity, arguing that preservation of a living herd in captivity would atone partially for America's extermination of the species.



Hoping to reunite the Hornaday Buffalo Group, writer and conservationist Doug Coffman tracked down several of the six members at a University of Montana storage facility.

In 1888, Hornaday and Smithsonian Secretary Samuel Langley drafted the zoological park proposal and forwarded it to congressional sponsors. The bill finally passed in 1889. Said a sponsor, Senator James Beck of Kentucky, "It is the duty of the National Government to secure a herd of American bison, and preserve it under the best conditions."

The legislation established the Zoological Park Commission to oversee the park's construction. Langley named Hornaday as temporary superintendent. Through donation, the Zoo soon acquired six buffalo, the first living buf-

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falo specimens to be the property of the U.S. government. Their preservation as a living display exemplified the zoological park ideal that would guide American zoological gardens for the next half-century.

The Buffalo Group would have to go, even though it contained the last wild buffalo.

Since Hornaday's era, the number of buffalo on American soil has skyrocketed, thanks to his efforts and others. In 1902, twenty-one captive bison and 23 wild animals in Yellowstone National Park formed the nucleus of the herd of about 2,500 that survives there today. Meanwhile, other herds throughout North America, including protected herds and livestock animals on ranches, bring the total number of bison to about 250,000 animals. To some extent, all, in the United States at least, owe their survival to Hornaday.

Positioned as they were in the original Smithsonian display, the Hornaday bison now stand in the new wing of the Montana Agricultural Center and Museum.

Hornaday's Buffalo Group remained on display at the Smithsonian for almost 70 years after its first unveiling in 1888. From 1911 until 1957, the Buffalo Group stood on the first floor of what is today the National Museum of Natural History, across the Mall from its original location.

In 1955, the Natural History museum's mammals division began its mid-century modernization project. By the 1940s, dioramas—displays that included painted composite backgrounds behind mounted animals and accessories—proliferated in North American natural history museums. For the modernization project, the mammal curators hoped to update the displays of the larger North American quadrupeds. The Buffalo Group would have to go, even though it contained the last wild buffalo. Not only did the Buffalo Group seem old-fashioned by the mid-20th century but the skins had not been mounted to the standards of 1950s taxidermists, who used hollow plaster-and-burlap molds rather than Hornaday's wood-and-clay forms.

When, in 1957, twenty years after Hornaday's death, the Buffalo Group was dismantled and curators found the note from Hornaday, they treasured it, but they chose not to heed its advice. They moved the six Hornaday buffalo downstairs to the basement and replaced them with a new display, employing fresh and handsome pelts of animals recently killed in the National Bison Range in Montana, which Hornaday had helped establish in 1908. The new buffalo skins, unlike their predecessors, did not belong to animals that had ever been free.

But the Hornaday buffalo did not stay long in the dusty Washington, D.C. basement. Instead of rotting away to "dust and ashes," in 1958 the specimens—bull, spike bull, yearling, two cows and Sandy—were shipped to Missoula, Montana, where the University of Montana wanted to incorporate them into a small museum.

Instead, the school eventually distributed the specimens to various other sites in Montana. The large bull—the "splendid animal"—was given to the Montana Department of Fish, Wildlife and Parks, where it remained until it was acquired in 1970 by Jack Lepley, director of the Montana Agricultural Center and Museum in Fort Benton.

But in 1988, Doug Coffman, a writer and naturalist in Eugene, Oregon, read about Hornaday's Buffalo Group and decided to track down its components. Coffman had become interested in the group as a symbol not only of the buffalo and their near extermination but also of the birth and many successes of the American conservation movement.

Between 1988 and 1990, Coffman located and documented all six specimens, and he and Lepley found funding to reunite the "family." Taxidermists were commissioned to restore the six old buffalo, even cleaning their still-original glass eyes. Reunited and refurbished, today the group stands in the new wing of the Montana Agricultural Center and Museum as a shrine to history and memory—to the buffalo's loss and rebirth, and the group's dispersion and reunion. The resurrected version is not encased but stands on a pedestal surrounded by guardrails. Instead of the old glass case, only an invisible fence of history—the passing of years, miles and lives—remains to separate visitors and buffalo.

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When Permafrost Isn't

SLOWLY RISING TEMPERATURES ARE MELTING THE FROZEN GROUND THAT UNDERLIES MOST LAND AT HIGH LATITUDES

BY BERNICE WUETHRICH

Vladimir Romanovsky collects data from a remote station in Alaska's Brooks Range.

WHEN I WAS A GIRL OF 5, MY FATHER LEFT ME ALONE on the summit of a mountain in the Alps while he fetched my mother and infant brother from the trailhead below. All around me was ice, snow and sky. The world vibrated with light. Ever since, I have taken comfort in the cold places on earth and embraced their bright and solid beauty. Now it troubles me to think that some of those cold regions are warming, ice frozen underground is melting and the stark glory of whole ecosystems is changing. I am talking of those subarctic and arctic regions that are based on permafrost—permanently frozen ground—that supports forests of spruce and birch and tundras of feathery moss, the stomping places of moose and caribou.

To see the melting for myself, I travel to Fairbanks, Alaska, and from there north to Prudhoe Bay, where two cold-adapted scientists have been probing the permafrost. Tom Osterkamp, a geophysicist at the University of Alaska, Fairbanks, began the studies in 1977, drilling 60-meter holes into the frozen ground and measuring the temperature at one-meter intervals. He was joined a few years ago by Russian-born scientist Vladimir Romanovsky, with whom I drive up from Fairbanks.

We stop half a dozen times to take the permafrost's vital signs, trekking out across the scarlet-and-gold tundra, armed with probe, computer and shotgun (in case of wayward grizzlies). When we reach the array of pipes and flags that mark an automated field station, Romanovsky checks the site's small solar panel and downloads four seasons' worth of air, surface and permafrost temperatures. Then we begin a paced walk. After every eight strides, Romanovsky thrusts a metal probe through the soft surface peat until it strikes impenetrable permafrost.

After years of doing this at some 30 sites around the state, Osterkamp and Romanovsky are discovering patterns of change. Between the late 1980s and 1998, the mean annual temperature of the active layer and the top of the permafrost rose as much as 6.3 degrees Fahrenheit north of the Yukon River. South of the Yukon, the permafrost warmed between 1 and 2.7 degrees F. Here the permafrost is discontinuous and already warm—usually within one or two degrees of melting, so just a slight rise in temperature can tip the balance. It is melting at the rate of about a meter a decade. Farther north, the permafrost is colder to begin with, requiring more heat to initiate a thaw.

The data raise haunting questions. If warming contin-

With a satellite antenna that could be radioing for help, a house outside Fairbanks settles slowly into the melting ground.

BERNICE WUETHRICH (2)

Left: Slumping caused by thawed permafrost cracked this road near Fairbanks. Below: Geophysicist Tom Osterkamp checks surface temperatures at the University of Alaska.

ues, how will melting permafrost transform landscapes? Will forest grow in place of tundra? Will wetlands rise where forests once grew? And will these changes affect the carbon balance, as the now-unfrozen soil emits greater quantities of carbon dioxide (CO_2), a greenhouse gas that traps heat in the atmosphere?

Osterkamp believes answers will be most readily found in Alaska's interior, from the banks of the Tanana River to the flanks of Mount McKinley, where we visit one of his favorite sites. The scent of Arctic sage suffuses the air as we navigate high clumps of grass and pools of water. In less than 15 years, this once-level meadow has become a mosaic of ponds and pits and water-bound plants. The new topography, called thermokarst, got its name from karst terrain first described in Poland, where weathered limestone is pocked with sinkholes, pits and troughs. Thermokarst is karst produced by heat. While North America's highest peak rises as regally as ever, ground around its base is sinking.

We jump across a trough that formed when underground ice melted. It provides a clue to the processes beneath our feet. Within permafrost is ice: sometimes countless crystals in the pores between soil particles; sometimes huge interlocked wedges that began life in small surface cracks; sometimes lenses the size of a skating rink. The melting of ice-rich permafrost can destroy the physical foundation of everything above: tundra and forests, houses and roads.

In Alaska, permafrost has warmed in response to air temperatures that have risen since the late 1800s, and particularly in the past 20 years. During much of the past decade, change has also come in the form of deeper snow that can insulate permafrost from cold winter air, allowing it to keep its summer glow. Climate models predict that air temperatures in the Arctic will rise as much as 9 degrees F in the next half-century, fueled in part by increasing levels of greenhouse gases.

What of other permafrost regions? In Canada, Russia, China and Mongolia, scientists also see widespread permafrost degradation. In China, the southern limits of permafrost are believed to be moving northward at about a mile a year. Vast areas—up to 25 percent of the exposed land surface on earth—are underlain by permafrost, including isolated pockets in the Alps and Pyrenees, and on mountain slopes in southern and eastern Africa, Chile and Argentina. All this frozen ground stores huge quantities of carbon; northern ecosystems alone contain the equivalent of 60 percent of the carbon currently in the atmosphere as CO_2.

Eighty-year-old black spruce, scrawny as pipe cleaners, grow on north-facing slopes near Fairbanks. In their shadowy understory, mosses and lichen thrive. Here the active layer above the permafrost is less than two feet deep. Turn over a spadeful of peat, and there is the carbon source: black soil, bits of branches, insects, roots living and dead, an organic mat you can squeeze like a sponge. Warming of this active layer would increase microbial activity and hasten the decomposition of dead organic matter, releasing its carbon. Furthermore, if warming deepens the active layer, peat that was previously permanently frozen would also be exposed to decay, releasing yet more CO_2. These dynamics could create a simple cycle: increased air temperature, deeper thaw, more CO_2, increased air temperature.

But nothing in nature is so simple. As tundra warms, the tree line may migrate north, and the fresh growth of forest may soak up more carbon from the atmosphere than the soil releases. In areas of discontinuous permafrost, where forests topple as the ground collapses, emerging wetlands may also sequester more carbon than the forest that preceded them. On the other hand, climatic warming is already increasing the acreage of Northern forest that burns every year, a trend likely to accelerate—and burning forest releases huge amounts of CO_2. We just can't be sure how these forces will play out.

One thing we can be sure of is the critical role of the peat and moss that cover permafrost. Destroy that layer of insulation, and the ground will be as exposed to the sun as is bare skin. Yet, in our zeal to build, we often ignore the guardian role of moss and peat. All around Fairbanks, land has been cleared of forest and moss to build homes, hundreds of which are now settling at odd angles as permafrost thaws. In Kotzebue, a hospital damaged by melting permafrost was abandoned. So was a radio transmitter site near Fairbanks, and miles of roadway across interior Alaska.

It is earliest autumn, and as I drive with Tom Osterkamp on the road to Mount McKinley, he exclaims with delight whenever he sees a yellow birch. The road heaves and dips and falls away at the shoulder into newly formed pits and pools of meltwater. "Thermokarst," he points out, again and again. I have grown to recognize it, as I suspect will many others, as climate and land change.

BERNICE WUETHRICH (2)

Mom Earns Another Stripe

SMITHSONIAN HIGHLIGHTS

THEY ARE SO DARN CUTE THAT THE DESIRE to cuddle them is powerful. The National Zoological Park's new Sumatran tiger cubs have plenty of admirers. Yet it's really their mother, Kerinci, seen here taking a playful swipe from cub Eric, who deserves recognition. The cubs, Mike, Eric and Chrissie, born June 24, 1999, are Kerinci's third litter, and at age 15, old age for most tigers, she's still going strong. Motherhood is apparently keeping the grande dame of the Great Cats exhibit healthy. "She is acting like a cub herself," says Curator of Mammals John Seidensticker. "Kerinci is a great mother; she's continually instigating play and she's very sensitive to her cubs." Zoo tigers are not exactly wild animals; Kerinci is habituated to people. She doesn't mind, for example, when keepers approach her cubs. Kerinci is regarded as an ambassador, a representative of her wild counterparts, because she helps the Zoo educate visitors on the increasingly important conservation efforts for the 500 or so Sumatran tigers that remain in the wild. She also serves as an insurance policy; she is a vital part of a carefully planned breeding population of Sumatran tigers in the world's zoos. Thus, through her offspring, she contributes to the genetic diversity of those animals. But it's hard not to think of her in purely human terms, too. For just like any other mom, at the end of the day she's exhausted. So her cubs get sent off to play by themselves and Mom gets a little peace and a chance for some much-needed R and R. —*Beth Py-Lieberman*

JESSIE COHEN/NATIONAL ZOOLOGICAL PARK, SI

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SMITHSONIAN HIGHLIGHTS

Black History Month

A CARNIVAL, AN EXHIBITION AND A MASQUERADE BALL

On February 4, "Reflections in Black: A History of Black Photographers, 1840 to the Present," opens in the Arts and Industries Building. Showcasing more than 300 photographs, this touring exhibition is organized by the Anacostia Museum and Center for African American History and Culture. Curator Deborah Willis, a photographer, historian and author of a book of the same title on which the exhibition is based, says this is a long-overlooked chapter in American photography. African-Americans, Willis says, were pioneers in the medium. Among the photographers featured in the exhibition is Jules Lion, who began making daguerreotypes in New Orleans in 1840, one year after the invention of the process. The portrait of an unknown woman from about 1890, below, comes from a cache of thousands of images from the studios of J.P. Ball and Son, an enterprise supported by an emerging black middle class in Helena, Montana. The exhibition will be on view through June 30, 2000, before starting a nine-city tour. Other observances for Black History Month include a children's carnival at the Washington Convention Center on February 5 and a masquerade ball on February 26, with guests appearing in festive carnival masks or as noted figures from African-American history. Tickets are $125 per person and raise funds for the education and outreach programs offered by the Anacostia Museum and Center for African American History and Culture. For more information on these events, call 202-357-2700.

African-American photography is on view in the Arts and Industries Building.

Renovations Continue

ART MUSEUMS AND ANACOSTIA GALLERY CLOSED

The National Museum of American Art and the National Portrait Gallery are closed for the next three years. The Anacostia Museum gallery will reopen in spring 2001.

SMITHSONIAN Website

WWW.SMITHSONIANMAG.SI.EDU

Visit our homepage and click on "Events" to see more images of the National Zoological Park's new Sumatran tiger cubs (p. 34). The on-line calendar is designed so that visitors can view on-line versions of these exhibitions, as well as the Websites of all the Smithsonian museums.

Exhibitions and Events

SMITHSONIAN ASSOCIATES

Registration is under way for this summer's study tour to Canada's Hudson Bay, led by Bill Fitzhugh, director of the Smithsonian's Arctic Studies Center and curator of the National Museum of Natural History's upcoming exhibition, *Vikings: The North Atlantic Saga* (April 29 through September 4). The tour begins at Leif Eriksson's North American settlement at L'Anse aux Meadows (above) and continues across Hudson Bay.

At L'Anse aux Meadows, study tour participants will see a Viking encampment.

NATIONAL MUSEUM OF AFRICAN ART

A Concrete Vision: Oshogbo Art in the 1960s (January 23 through October 22) Works by participants in the 1960s artistic renaissance that developed in the western Nigerian town of Oshogbo, including *The Rich and The Poor* (p. 38) by Muraina Oyelami.

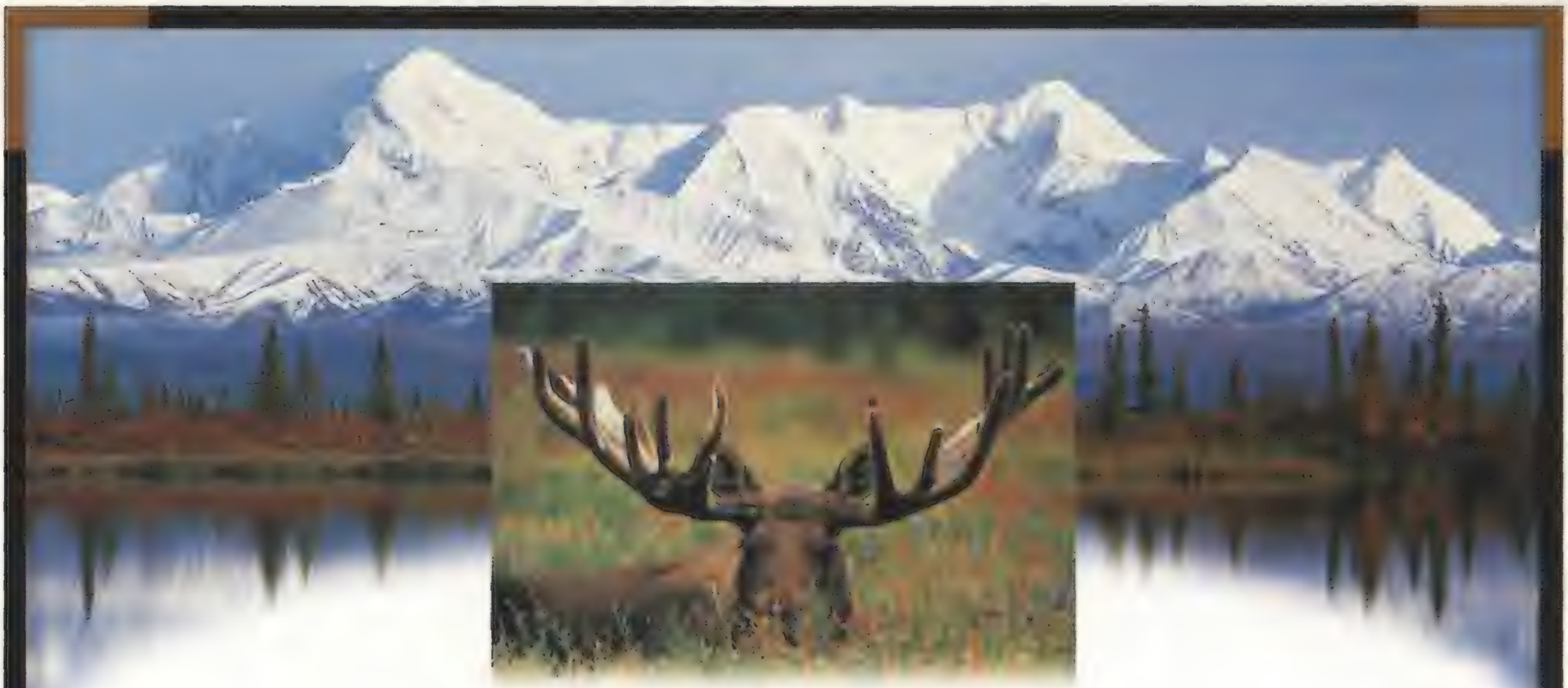
ARTS AND INDUSTRIES BUILDING

The Artistry of Orchids (through March 26) Specially designed gardens filled with hundreds of orchids from the collections of the Smithsonian's Horticulture Services Division and the U.S. Botanic Garden celebrate the family Orchidaceae.

NATIONAL MUSEUM OF AMERICAN HISTORY

Make the Dirt Fly! Building the Panama Canal (through January 5, 2001) A Smithsonian Institution Libraries exhibition on the ten-year project.
On Time Explores ways Americans

TOP: SHANE KELLY/PARKS CANADA; BOTTOM: MONTANA HISTORICAL SOCIETY



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CRUISES

The Rich and The Poor (1971) by Muraina Oyelami is on view at African Art.

have measured, used and thought about time over the past 300 years.
Preserving the Star-Spangled Banner: The Flag that Inspired the National Anthem Observe the conservation process.

NATIONAL MUSEUM OF NATURAL HISTORY

African Voices A new permanent exhibition examines the diversity, dynamism and global influence of Africa's peoples.
In Place of Prairie (through March 7) Award-winning photographer Terry Evans explores the diversity of prairies and the people who settled them.

NATIONAL AIR AND SPACE MUSEUM

Curator's Choice A special lecture series celebrating Black History Month will take place each Tuesday in February at noon in the Space Race gallery.
Flights of Fancy On Saturdays, February 5, 19 and 26, at 11:30 in the How Things Fly gallery, staff will read African folktales and books by African-American authors to children ages 3-7. Hands-on activities will follow. To make reservations, call 202-786-2107.

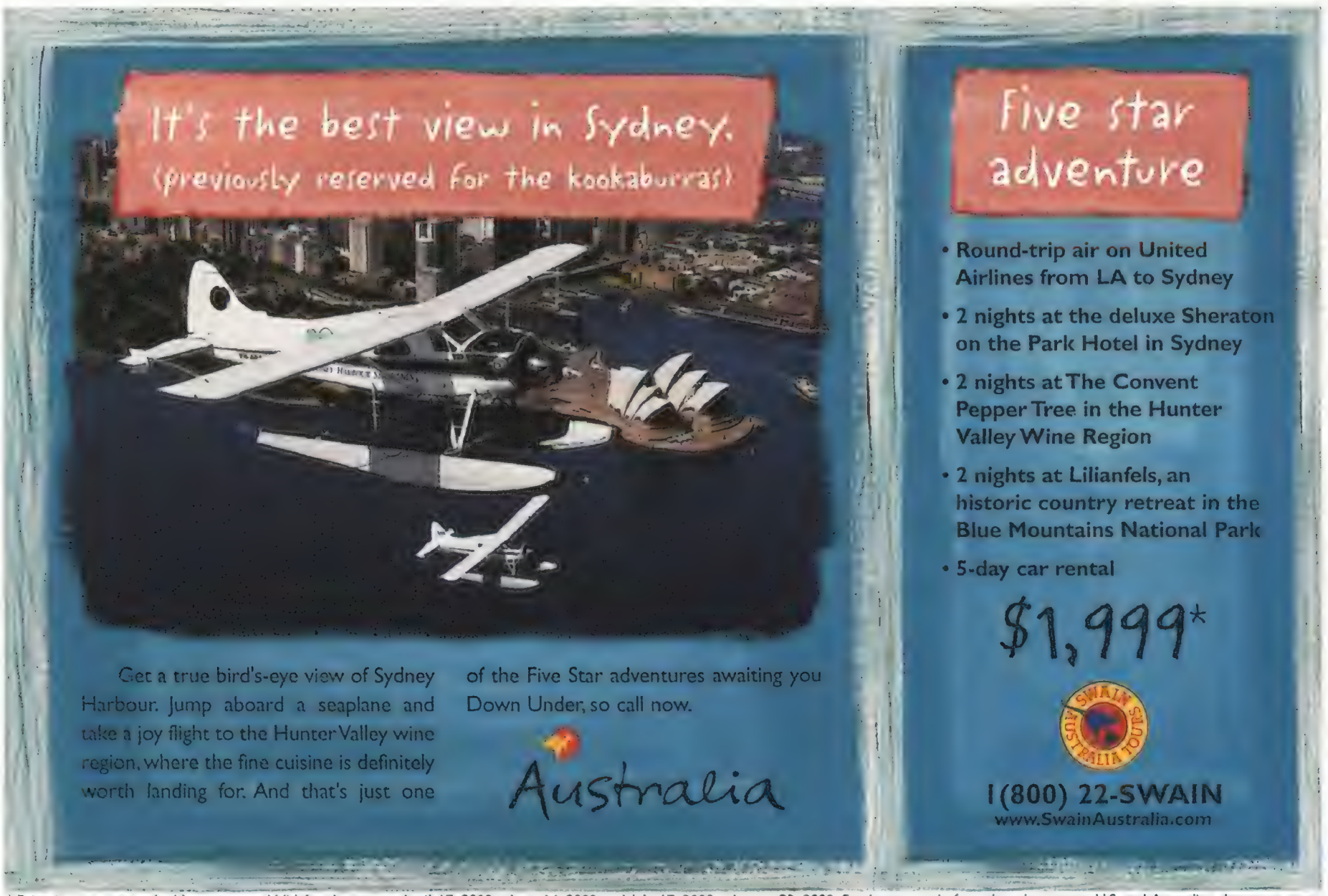
HIRSHHORN MUSEUM AND SCULPTURE GARDEN

Robert Gober: Sculpture and Drawing (February 24 through April 23) Includes 100 drawings, a group of sculptures and a slide-projection installation. Gober's altered images of sinks, drains, chairs and twigs explore themes of childhood, memory, loss and sexuality.
Directions—Shahzia Sikander (through February 21) Some 30 works on paper and a mural by the American-based Pakistani artist.

NATIONAL POSTAL MUSEUM

Missing You: Last Letters from World War II (through April 30) Letters sent home before the writers were killed in action.
Posted Aboard R.M.S. Titanic (through June 12) Artifacts recovered at sea memorialize five sea post clerks who died when the great ship sank.

COLLECTION OF MIMI WOLFORD/MBARI INSTITUTE FOR CONTEMPORARY AFRICAN ART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ARTHUR M. SACKLER GALLERY

Antoin Sevruguin and the Persian Image (through May 28) Sevruguin's evocative photographs record Iran's culture. *Constructing Identities: Recent Works by Jananne al-Ani* (through February 28) Photographs and a slide-projection show challenge the stereotype of the "Oriental" female. *Imaging the Word: Selections of Calligraphy from the Islamic World* (through May 7) Some 30 works from the museum's collection on paper, parchment, textiles, coins, gemstones and metalwork, dating from the 9th to the 20th century, show the variety of calligraphic styles.

FREER GALLERY OF ART

The Dragon's Moan (February 6 through October 1) Works celebrating the *qin*, or zither. Three qin, one from the original Charles Lang Freer bequest in 1915 and two that were gifts in honor of the Freer's 75th anniversary in 1998, along with artworks, relate the history of one of the most important Chinese musical instruments.

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[NEW YORK CITY]

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THE CASTLE—INFORMATION CENTER

Begin your visit at the Associates' Reception Desk in the Castle's Smithsonian Information Center—open 9 A.M.-4 P.M. daily. Special materials and information on exhibitions, activities and dining are available there. Learn what's new at the Smithsonian and about other area attractions—with brochures, videos, touch screens, electronic maps and more. Smithsonian museums are generally open 10 A.M.-5:30 P.M. daily, except December 25. To receive a free Associates' planning packet, write to Smithsonian Information, Smithsonian Institution, Washington, D.C. 20560-0010, or send your request via e-mail to info@info.si.edu, or call 202-357-2700 (voice) or 202-357-1729 (TTY), 9 A.M.-5 P.M., Monday-Friday; 10 A.M.-4 P.M., Saturday-Sunday. Note: Parking on the Mall is limited; Metrorail is convenient to most museums.

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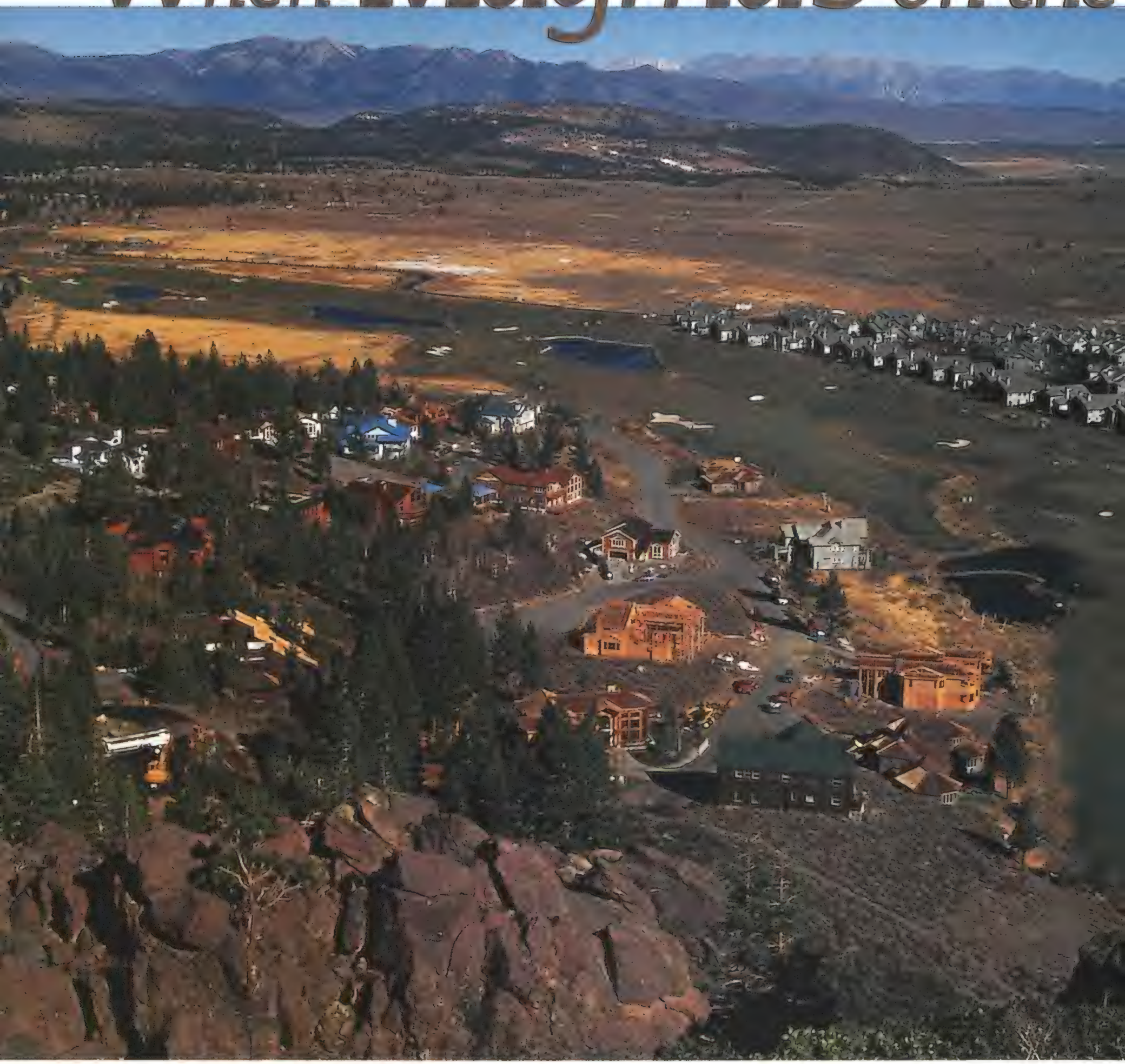
When Magma's on the



Above: The sparse, seemingly insignificant hill rising, top center, near the town of Mammoth Lakes is a "resurgent dome" being pushed up by hot magma. Opposite: Fumaroles provide more evidence of hellish conditions deep underground.

Move

In California's Long Valley, the earth trembles every day where a volcano once exploded

BY MARK WHEELER

THE OLD CANARD AMONG THE geologically challenged is that some day an earthquake with a magnitude of, oh, 9.0 or so, will strike California, causing the entire state to drop into the sea.

That last isn't going to happen, but spend enough time with Dave Hill in the Long Valley caldera, 300 miles north of Los Angeles, and you begin to wonder what will. Hill is a seismologist for the U.S. Geological Survey (USGS), and the chief scientist for the Long Valley caldera, a crater left when a volcano exploded 760,000 years ago.

Since 1980, earthquakes have been occurring there daily, not singly but in swarms. That gives the caldera the dubious distinction of being the most earthquake-prone spot in the contiguous United States. For the past 20 years, the area has experienced anywhere from a handful to 100 quakes a day.

Most of them occur deep within the earth and are so small they can't be felt by people, just by seismometers. (Unless you're right on the epicenter, it usually takes a magnitude 3.0 before the walls start to creak and the glassware to tinkle.) These little temblors are nothing, too, when compared with the likes of such devastating earthquakes as the magnitude 7.4 that struck Turkey last August, or the 6.7 Northridge quake of 1994.

Still, for day in, day out, rock and roll, nothing beats the Long Valley caldera, especially when things get busy. That's what happened in November 1997 when the area was struck by

PHOTOGRAPHS BY ERIC SANDER

more than a thousand earthquakes in a 48-hour period. These included temblors with magnitudes of 4.8, 4.7 and 4.5, along with another 20 or so that registered between 3.0 and 3.8. Last May, in a year that was otherwise geologically somnolent, a magnitude 5.6 reminder struck just south of the caldera, but with little fanfare. If a 5.6 had struck in Los Angeles or San Francisco, it would have been front-page news.

Ironically, though, it's not the earthquakes that make Long Valley caldera unusual or that at times keep Hill lying awake at night, staring at his bedroom ceiling. What worries Hill is that for nearly two decades, the caldera has been showing every sign that it could erupt, producing as much magma as did Mount St. Helens.

An eruption would be a disaster, because not only are there people living in and around the caldera, but a major ski resort is there, attracting thousands of skiers and other vacationers. The building of second homes has become big business.

The Long Valley caldera butts up against the steep eastern face of the Sierra Nevada. A volcanic explosion thousands of years ago created this particular 10-by-20-mile oval depression, and scientists like Hill are wondering if things here are starting to heat up again. Geologists know that earthquake swarms can serve as an early warning of volcanic unrest, indicating that magma—hot, molten rock from deep underground—may be squirming its way toward the surface. Such swarms were one of the signs at Mount St. Helens just before the side of the mountain disappeared in 1980, at the Mount Pinatubo eruption in the Philippines in 1991 and at the Soufriere Hills eruption on the Caribbean island of Montserrat in 1995.

Worse, in Long Valley the swarms have been accompanied by other signs that can be precursors of an eruption: an ominous bulge in the center of the caldera continues to grow, presumably pumped up by fresh injections of magma; since 1994, large stands of 300-year-old trees on the edge of the caldera have been dying, killed by carbon dioxide upwelling into the soil, once again coming from magma.

The signs rise and fall, each time ratcheting up the nerves of the scientists. They have covered the caldera with instruments that measure the strength and location of the earthquakes, the incremental increases in ground deformation and the chemical composition of gases vented from fumaroles. Yet, so far, each time the signs build and build in intensity, they are followed by . . . nada. Nothing. No Mount St. Helens-like explosions, no sudden, destructive flow of lava (what magma is called once it reaches the surface), no plume of ash rising miles into the sky. It will happen, but no one is able to predict when.

David Hill and I are walking down a narrow road, about 30 miles south of Long Valley and 10 miles north of Bishop. It is a hot day, the air still, the road dusty. About 40 yards ahead of us is a group of 25 dusty people being led by Roy Bailey, a colleague of Hill's and an emeritus scientist with the USGS. The group is mostly composed of earth scientists, who are all independently conducting research on Long Valley caldera. To compare notes, the group returned to the High Sierra, and part of the get-together was a daylong tour to see some of the geologic sights in and around Long Valley.

The rocky road we're walking on is owned by the Los Angeles Department of Water and Power, which controls nearly all the water rights here in the Owens Valley. This land was lush and green until the department got hold of it. Now it's desert, a place of chaparral, volcanic rocks and sand. Lots of sand. Before getting out to walk, we had bounced along the road in Hill's truck. Paralleling the road was a silver pipe, taller and wider than the truck, which is part of the Los Angeles aqueduct that carries water south to the city.

Now, though, we've left the pipe and truck behind and continue on foot; Hill is talking about earthquakes.

Carbon dioxide from magma killed these trees. Seismologist David Hill (inset) has worked here 25 years.

"With all the activity in the caldera," he says, referring to the many small quakes, "there's no reason to think there couldn't just as easily be a magnitude 6.5 or even a 7.0. That could do some damage." As he says this, I'm eyeballing a 20-foot wall of crumbling rock looming overhead to our left. It's not a comforting sight, as Dave Hill has warned that aftershocks can produce rock falls.

California, of course, has a history rich with earthquakes. The state sits on top of the boundaries of two tectonic plates, the North American and the Pacific. As a result, the state is laced with faults—fractures in rock caused by the shifting of the earth's crust. For the past three million years a fault system running the 400-mile length of the Sierra Nevada has been shoving the mountain range up (peaks of 10,000 to 14,000 feet are routine) and tilting it to the west, and at the same time pushing the Owens Valley, which runs along the Sierra's east side, down. Over time, the topography has been sculpted by glaciation and weathering.

While the Sierra fault zone is not as well known as the San Andreas, it has had its share of severe earthquakes. In 1986, not far from where we now walk, a magnitude 6.4 earthquake struck in the area known as Chalfant Valley. One struck in 1872 at Lone Pine, 100 miles south of the caldera, destroying the town and killing 27 people. Although the quake occurred before the invention of seismographs, modern geologists estimate its magnitude at 7.6-8.0.

Other researchers had explored and mapped the area, but Bailey and a colleague were the first to identify the Long Valley caldera in 1968 as a "resurgent" caldera, a collapsed volcano containing a growing, magma-fed bulge. Since then, Bailey has spent years, and worn out who knows how many pairs of hiking boots, laboriously studying the caldera's rocks, ancient lava flows, pyroclastic deposits and other volcanic debris. Learning a volcano's history is important in anticipating future eruptions, and over the years, Bailey identified many of the types and magnitudes of old eruptions.

It may be difficult for the layperson

to understand Bailey's jargon as he talks to the group of visiting scientists, but it's possible to get the drift when considering the visual aid behind him, because five feet beyond Bailey is an awesome sight. There, the ground ends, plunging straight down some 400 feet to a river. The cliff we are looking at across this gorge is made of Bishop tuff, "tuff" being a type of rock composed of compacted volcanic ash.

It is powerful evidence of the cataclysm that formed the caldera. Way back when, a single, huge chamber of magma, four miles deep, underlay the terrain where the present-day caldera now sits. Then, about 760,000 years ago, a volcanic explosion blew out 150 cubic miles of magma; a fast-moving and turbulent flow of lethally hot gas and debris quickly buried a 350-square-mile area. Known as a pyroclastic flow, it leveled everything in its path and laid down a carpet of ash 500 feet thick; the flow and airborne ash created this rock formation, subsequently cut by the river. At intervals along the cliff are columns of curving rock; Bailey calls them "rosettes," remnants of ancient fumaroles, vents where steam blasted its way out. Ash was blown as far east as present-day Nebraska and as far south as today's Los Angeles. The explosion caused the roof of the magma chamber to collapse, dropping the overlying ground more than a mile and forming the caldera.

Within the caldera itself, the Bishop tuff is not exposed on the surface, although the ash that would eventually harden to form the tuff fell back into the caldera during the explosion. It's subsequently been buried by what Bailey calls "post-caldera" activity, meaning more ash being ejected from other, nearby volcanoes, along with the glaciation that came along later, covering the caldera with other kinds of rock and soil. Indeed, some 10,000 years ago the caldera was entirely filled with water; icebergs from the glaciers would have been floating about, says Bailey.

As the group clambers back into the trucks, Hill gives me a lesson in the volatile geology of Long Valley. The force of any eruption is strongly influenced by the chemical makeup of its magma, he explains. Bishop tuff—rhyolite—is about 73 percent silica. In magma, the greater the silica content, the greater the viscosity, or resistance to flow. Or, in other words, the greater the viscosity, the slower the lava will flow.

So why the explosion? Why didn't the lava simply ooze out, like toothpaste? "Because the more viscous magma is, the more gases it can hold in," says Hill. "Since the magma has a high content of silica, the viscosity—the thickness—also holds in these gases, stuff like carbon dioxide and sulfur dioxide." Presumably, says Hill, when the magma eventually worried its way through fissures in the rock to finally reach the surface, it was almost instantaneously released from the intense pressure caused by the earth and rock that pressed against it; that sharp pressure drop allowed the gases trapped in the magma to explosively expand.

But complicating the picture is another "explosive chemical" that lurks everywhere beneath the real estate of the caldera: water. The pools of magma that underlie Long Valley also heat and pressurize pools of underground water. The water feeds hot springs that locals and tourists like to soak in, and it produces natural steam vents. The hot water even drives three geothermal power plants, which together produce enough electricity to power a small town. All this water makes the area ripe for a phreatic explosion: when magma penetrates a body of underground water, the water flashes to steam.

Most Californians who are familiar with this part of the state don't call it the Long Valley caldera. Instead, they call it Mammoth Mountain, Mammoth Lakes or simply Mammoth. Mammoth Mountain is a 11,053-foot dormant volcano that's perched in the southwest end of the caldera. It's also a major ski resort, the West's second largest after Vail, Colorado. Obviously, a ski resort's survival depends on the skiers who come each winter. The town of Mammoth Lakes, with its restaurants, shops and active real estate market in second homes, is dependent on year-round tourism.

Scientist Roy Bailey (inset) studies aerial photographs of cliffs formed from volcanic ash turned to rock.

The area received a nasty wake-up call on Memorial Day 1980, when four magnitude-6.0 earthquakes hit in a 48-hour period. Hundreds of smaller quakes followed. Together, the temblors caused avalanches and rockslides, buckled the ground, and cracked walls and chimneys. Research in 1981 through 1982 found that the resurgent dome had bulged another ten inches since it was last measured in 1978. At the time, the evidence indicated that the earthquakes were becoming more shallow, suggesting the possibility that it was not tectonic faulting that was causing the quakes but magma moving closer to the surface. "You have to remember, too, that this was not long after Mount St. Helens," says Hill, "and we were observing a pattern that was very similar to the events that preceded that eruption." That was a scary thought because in Washington State, despite careful monitoring of the volcano, people still died.

When the swarms persisted, the USGS finally issued the lowest level volcanic alert, notifying residents and the media of a "potential volcanic hazard." The swarm of earthquakes was occurring under the intersection of highways 395 and 203, the latter the lone access into Mammoth Lakes. State and local officials, fearing an eruption would cut off the town, demanded that a secondary escape road be built that would provide vacationers and residents another way of fleeing any eruption or lava flow.

All of this was very bad news for the locals who, until the infamous Memorial Day weekend, had not even known they were living in a volcanically active area. Earthquakes, they could understand. This was, after all, California. But volcanoes? Still, all they could do was watch as tourists fled, real estate prices plunged and their own incomes headed south.

Then, says Hill, in the typical manner in which the geology in Long Valley can be, as he puts it, "perverse," nothing happened. No eruption occurred. "No more temblors," Hill smiles ruefully. "Everything quieted down." The locals were outraged, deriding the USGS as the "United States Guessing Society." A new sign was quickly erected by the

No large pool of magma underlies the caldera anymore. Instead, there are separate, smaller pools.

new escape route, naming it the Mammoth Scenic Loop.

Still, the agency's concern was not unreasonable. The possible scenarios were frightening. A 1987 multiagency report stated that even in a moderate eruption, flows of hot ash and gas could bury buildings and forests or set them on fire. If it happened in winter, the hot ash could melt snow, creating floods and mudflows that could be devastating.

"I think it's fair to say there was grinding of gears between the local businessmen, the people in the town and the USGS," says Wally Hofmann, publisher of the local newspaper, the *Mammoth Times*. "The USGS wasn't great about communicating information to us back then."

The situation also wasn't helped by the outside media, says Hofmann. He cites as one example the Los Angeles TV station that did a report on the volcanic activity in the area. As a background, they used an exploding Mount St. Helens. That caused many people to think that it was Mammoth Mountain itself that had erupted, exacerbating the situation.

Hill winces when reminded of the media. "We didn't help ourselves any, either," he says, "because a reporter from the *Los Angeles Times* somehow got wind that we were issuing the alert, and published it before we had a chance to alert local officials."

The agency, says Hill, was embarrassed—but also frustrated. After all, what was it supposed to have done? Say nothing? Then what, should an "event" actually have occurred? "At that time, most of the residents had no idea they were even in a volcanic area or living within a caldera," recalls Hill. The animosity was such, says Hill, that "years later I stayed at the same motel when I went to Mammoth because it was the only place that would take me."

Hill remains the man in the hot seat. Each time the caldera starts to show life, it's up to him to read the geologic signs and decide whether he should implement the USGS's "Response Plan for Volcanic Hazards." The plan refers to what the agency will do in the event of any volcanic activity in the caldera. The advisories range from green (for weak unrest, the normal, day-to-day standard for the area), through yellow (intense unrest), orange (eruption likely), and finally, red (she's blowing!). In late November 1997, Hill came close to calling a yellow alert. Besides a severe swarm of earthquakes, the resurgent dome, which normally expands at a rate of about an inch a year, grew almost four inches between May and December of 1997, when things were shaking.

These days, relations have improved between the town and the USGS. People are more knowledgeable, and Hill has gone to great lengths to make his agency more communicative. Nonetheless, when the swarms come, everybody's a bit uneasy. "It does get stressful when the caldera gets restless, and you're uncertain what's going to happen for weeks or months at a time. When I went into science I had no idea I was going to be in this kind of a position," he says. "There was nothing in my textbooks about public relations."

The USGS's Adam Heffernan monitors a station from which lasers measure ground movement.

One bit of good news for the town is that few if any scientists believe that if an eruption were to take place it would be anything like the cataclysmic event that formed the caldera. No single, large pool of magma underlies the caldera anymore. Instead, says Hill, there are several smaller, separate pools, "like a

Bathers congregate in Hot Creek where warm water from geothermal vents mixes with cold stream water.

breakfast pastry that's sprinkled with raisins." Besides the one under the dome, there's at least one smaller pool under Mammoth Mountain, another in the northwestern part of the caldera, and possibly yet another under the intersection of the two highways, where the activity in the early '80s occurred.

While the rate of growth may vary during times of unrest, the dome still grows every year. Since 1979, the dome has risen 31 inches, presumably fed by repeated, fresh injections of magma into an existing pool. Logically, then, this is the place where an eruption is likely to happen.

Ironically, though, it's not, says Hill. "Certainly the magma's coming in at depth from somewhere, but it's not necessarily moving closer to the surface." He sees my blank look. "Think if you had a big chunk of foam rubber and had some way of sticking a balloon under it and blowing it up. You'd see a dome-shaped uplift on the surface. The whole thing would go up and stretch. That's what we're seeing here. So you can get uplift and extension of the dome without moving the balloon any closer to the surface."

I get it. Still, though, isn't nearly three feet of uplift in 20 years significant? "It is, but you have to keep it in perspective," says Hill. "The uplift at the Rabaul volcano in Papua New Guinea, for example, rose 16 feet in 27 hours just before the eruption in 1994," says Hill.

That evening I drive up Lake Mary Road, at the backside of Mammoth Mountain, to see the area of dead trees that have been killed by carbon dioxide escaping from under the ground. It is near a place called Horseshoe Lake and the campground that wraps around it. In 1989, after a series of small earthquakes under the mountain, USGS monitoring instruments showed that a small dike, an intrusion of magma, was rising closer to the surface.

Soon after, trees in the area began dying. At first no one linked the tree kills to volcanic activity: "We assumed it was some kind of bug infestation, or possibly a manifestation of a drought that was taking place at the time," says Mike Sorey, a USGS hydrologist. Scientists took a fresh look after a U.S. Forest Service ranger, seeking shelter from a winter storm, was almost asphyxiated when he entered a cabin that was nearly buried in snow near the tree kill. The culprit was carbon dioxide (CO_2), odorless and colorless. Because it is also heavier than air, CO_2 will accumulate at the bottom of tents, snowbanks, small depressions in the earth—and cabins nearly buried in snow. It displaces the normal air and its life-supporting oxygen.

Normally, soil gases have a CO_2 content of about 1 percent. In Horseshoe Lake, though, researchers determined that by 1994, the CO_2 content was as high as 80 percent. Plants, of course, require CO_2, taking it into their leaves and releasing the oxygen. But a tree's root system needs to take up oxygen, water and other nutrients directly. Because there was so much CO_2 seeping through the ground, the roots couldn't get what they needed. The trees suffocated.

To determine if the CO_2 had a magmatic source, the USGS looked at the ratios of various carbon and helium isotopes in the gas; magma pro-

duces a specific ratio. Samples were taken from cold streams ("some of the springs contain so much CO_2 it tastes like soda water," says Sorey), soil and fumaroles on Mammoth Mountain. In every case, the isotopic evidence pointed to magma as the source.

Other instrumentation determined that the volume of gas that's been escaping is too much to be coming from small gas pockets. At one point, the researchers calculated the amount upwelling through the soil at more than 500 tons of CO_2 every day.

Before leaving, I make a visit to Mammoth Mountain itself, hiking to a fumarole at the 10,000-foot level on the mountain's side. The vent gives off a steady blast of steam and stink. (I take a childlike delight in holding my hand over the vent's outpouring, nearly scalding myself in the process.) The mountain, still bare of snow, is bustling with activity as new and faster lifts are installed. Intrawest, a major resort development corporation, recently bought 60 percent of Mammoth Mountain and has already completed work on a condominium and lodge. Times are good, and business is building. Clearly, the threat of a volcano isn't a deterrent, and the ski mountain developers, as well as citizens, are counting on the long, long stretch between geologic events.

"As a community we were slow to come around to accepting the geology that we have here," says Pam Murphy, Mammoth Mountain's general manager, who has been a resident in the area since the '50s. "The earthquakes back in 1980 really caught us off guard. It took us until the 1990s before it finally became apparent that we needed to acknowledge that this area was formed by geologic activity."

Inside the caldera, this crater was created 550 to 600 years ago when hot magma flashed groundwater into steam.

And what of other local people who have planted roots in the community? I had dinner one night with five residents, all of whom had lived in Mammoth for at least ten years. One opinion was voiced by Brian Knowles, a newlywed who recently purchased his first home here.

"Right after we bought the house, there were several earthquakes in a row," says the 31-year-old, "and it was a bit unnerving. We were thinking, 'Oh Lord, what did we do?' But this is California, and this is a beautiful place to live. Earthquakes come with the territory. As for volcanoes," he laughs, "like most people here, we're just banking on the geologic timescale."

The next morning as I depart, I decide to make one last stop. At the southern boundary of the caldera, Mammoth Creek flows from west to east to the confluence where it empties into the Owens River. Before it gets to that river, though, the last stretch is called Hot Creek. Gazing down from a bluff, I can easily see why. Steam rises from vents and from several pools of boiling, sky-blue water; directly below, a small geyser of water, a few inches high, is popping and sizzling. In one large pool, several people are immersed to their chins in the hot water, ignoring the posted warning signs.

The signs are there because things can change here, and quickly. After a magnitude-6.2 earthquake in 1980, a 30-foot-high geyser boiled for several hours in this creek before dying out. Mike Sorey, the USGS hydrologist, told me that in 1997, one earthquake caused a foot-high geyser that would have cooked anybody sitting in the water.

Making my way down a narrow path to the water's edge, I feel an eerie sensation. The water snaps and bubbles, belching and frothing. Gingerly, I touch it. It's very hot. I reread a nearby sign: "Danger. Scalding water. Unstable ground. Keep out." While intellectually I accept the long odds of the geologic calendar, I can't help but recall Sorey's comment.

It takes faith to believe in scientists' interpretation of the geologic record. As I beat my retreat to high ground, I'm glad I don't have to fill the hiking shoes of a David Hill, the point man for the roiling real estate of the Long Valley caldera.

Mark Wheeler, a frequent skier at Mammoth Lakes, writes about science. Eric Sander is finishing a book on the West, Off Center.

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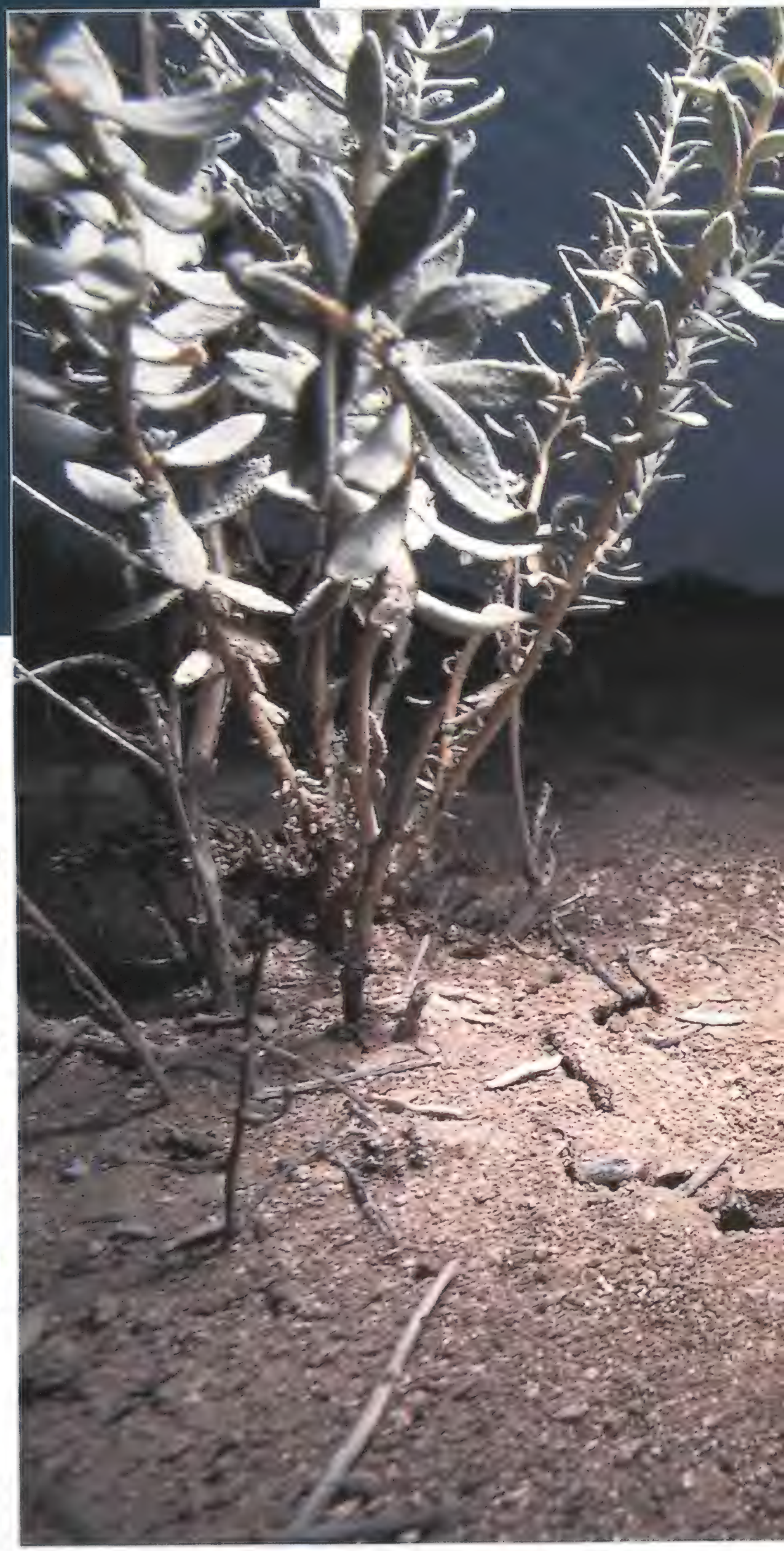
CLOSELY WATCHED BY THEIR GUIDES AND MILITARY ESCORT, HARRIED BIOLOGISTS SURVEY THE WILD THINGS THAT SURVIVE HERE

Casting Light on Iranian Deserts

TEXT & PHOTOGRAPHS BY MARK W. MOFFETT



Herpetologist Bob Macey comes across a sun spider devouring a baby gecko during a night collecting trip in a desert basin in southern Iran.

"WALK QUICKLY. I THINK WE CAN LOSE THEM," SHEDA MORSHED WHISPERS, LOADING THE last collapsible traps into an already jammed pack. At 6 P.M. the sun has lost none of its welder's torch intensity, forcing her to squint over a shoulder at the parked vans, jeeps and cars we have left strung along the road. Perhaps 15 people cluster around these vehicles, every one of them talking to somebody. At least two hold cell phones to their ears with a comfortable familiarity, gesturing to empty air. The voices merge into a drone of Farsi (the language spoken in Iran) variously confiding, anxious, serious, pushy, conspiratorial, officious. We Americans understand little of it.

The tamarisk shrubs provide scant cover, and so Sheda's chance of going unseen is slim unless we can make it behind the dune. Draped in her black, tentlike cloak, she is glaringly obvious in this open landscape of pastel sand and shrubs. Here in Iran, concealing attire is mandatory for women in public view above the age of 7. But in the heat her coverings are no longer merely constraining, they are physically intolerable. If we can evade our military escort, Sheda confides, she might at least remove her scarf. On another boiling day, in a mangrove swamp far from spectators, police had agreed that, yes, it would be OK for Sheda to uncover her head, then pulled out notebooks to write her up when she did. Getting comfortable is not easy in a country

The biologists are accompanied by soldiers and a truck-mounted machine gun.

where even singing in front of men in public is illegal. This does not stop Sheda from offering them the occasional opinion on women's rights.

Sheda is Iranian, but her family left for the United States when she was 7. Since then she has returned to her homeland only for brief intervals. A recent college graduate trying to qualify for a graduate biology program, she is here to work with Jim Patton of the University of California at Berkeley, one of four academics on this six-week expedition, the first team of American biologists sanctioned to do research in Iran in two decades.

I am one of those scientists, the mission entomologist. Striding beside Sheda, I scan the sand for my favorite organisms, the ants. Two other Americans, herpetologists Ted Papenfuss and Bob Macey, are circling brush in which they have no doubt cornered a lizard. They are watched by a man in military green hefting a machine gun, who fortunately takes no notice of Sheda and me.

Ted and Jim are my office neighbors at the Museum of Vertebrate Zoology on the Berkeley campus. Like me, Ted spends part of each day in Berkeley on the phone or on-line to remote and improbable countries, organizing his next expedition. My favored haunts tend to be rain forests in Southeast Asia and Latin America. Ted seems to prefer drier climes, like the mountains and deserts of Central Asia. Weather-beaten for his 58 years from treks across the Sahara and Inner and Outer Mongolia, Ted communicates with a wry smile and calm understatement, outwardly mellow under the most trying conditions.

He has organized this expedition, but only after testing the waters on a solitary trip to Iran in 1998. We have all been intrigued by his stories. The scientist he contacted met him at Mehrabad International Airport in an old (prerevolutionary) Chevy, "to make me feel at home." He found a driver who didn't mind chauffeuring a strange American who preferred stalking lizards to normal sightseeing. The two of them had gone north to the forests of the Caspian Sea. When Ted asked about a topographic map, the driver delivered him to a military station, where he was quizzed on American baseball before being provided anything he wanted. Hiking to a cave, he had found giant salamanders that ate bats, or at least bat babies that fell into pools from the ceiling above. At Ramsar, colleagues put him up at one of the palaces of the shah. He had gone as a tourist and had traveled almost unnoticed.

Adding three more biologists and arranging the trip as an official science mission makes a difference. Apparently the minimum number of Iranians required to escort four Americans is 20: an ever-shifting group of secret police, military personnel, scientists and graduate students, assistants to arrange food and shelter, and others of mysterious and at times vaguely threatening capacity. Plus, of course, drivers for all the additional vehicles. And finally, Oskouie, the mandatory government-provided tour guide, who understands little English and, despite his title, seems to know very little about his country: when we come upon an archaeological site where only knee-high foundations of rooms remain, he offers the local legend that the walls are short because they were built by midgets.

There may be legitimate reasons for the seemingly absurd size of our entourage. Whereas the northern sites Ted scouted on his solo excursion were politically uncontroversial, our expedition is focused on the southeast, a region best known today for drug trafficking. We'll even work at the Afghan border, where we had heard that camel trains weighted with opium were being captured or blown up by Iranian militia. It won't do for important visitors to come to harm, we are lectured. All these escorts are for our own good.

To the Iranians we may truly be important, not least as a political statement. Whether we should be allowed to come at all was apparently discussed in the press. Divisiveness of opinion about us must still exist at official levels in a country where symbols of disdain for the West are common. At one university we make an

effort to ignore a prominent "Death to America" banner hanging in the entryway of the Sciences Building. Still, the reception we receive is always warm. Biologists are delighted to meet us; many visited or studied in the United States before the revolution. A few travel with us for a time, becoming good friends.

A soldier has spotted Sheda and me. He peels from a knot of people at the parked cars and trots up the dune, slowing yards away to match our pace. I give a low curse, but am not surprised we've been discovered: Sheda is hard to miss, and not just because of her attire. Even cloaked, there is something about her that catches the eye: something different, American. Whereas Iranian women move in a smooth glide, she skips, bounces, dashes and weaves. From here I can see Soheila Shafii, an enthusiastic Iranian woman who studies reptiles at Shahid-Bahonar University. By comparison with Sheda, Soheila seems to float over the ground.

Under the guard's watchful eye, Sheda spaces the traps a few yards apart along a meandering line, positioning them at the base of tamarisk bushes. Her mentor, Jim Patton, is a mammalogist, and the spring-loaded traps are intended to catch rodents. Opening each trap, Sheda baits it with sunflower seeds, walnuts and barley, then marks its bush with an orange streamer. Somewhere out of view Jim must be setting a trapline along a transect of his own.

Sheda's scarf gradually slips back on her head as she works, until it threatens to fall to her shoulders. Nervously I motion toward her forehead. "Oops!" She covers her hair again with a sly grin, making me wonder if her veil slips so often because of inexperience or by intention.

Ted's first trip was to a comfortably warm, moist part of Iran, but conflicting schedules have put us in the hottest part of the country in the middle of a severe dry season. We have no thermometer, but temperatures reportedly approached 120 degrees Fahrenheit at another site we visited. More significant than the discomfort are problems collecting specimens. On most days I find only the most xeric (dry-adapted) ants, such as *Messor*, harvesting tufted seeds in columns up to six inches wide, and *Cataglyphis*, long-legged, swift ants undeterred by sizzling conditions. Many of the species I most desire seeing have moved far below ground to wait out this extreme weather.

We are near the Persian Gulf, where the habitat includes forms I

Left to right: Iranian biologist Soheila Shafii soaks her hat in a small waterfall to beat the heat; using a noose on a fishing pole, Ted Papenfuss lassoes a lizard; Jim Patton pins newly prepared rodent specimens to a tray for drying.

recognize from the Dead Sea of Israel and Jordan, among them biblical plants like apple-of-Sodom and Christ-thorn tree. It had seemed drier in the deserts we had visited in the north. Some resemble habitats we know from Southern California: water-leaching tamarisk (also called salt cedar) was introduced from this region to the United States at great cost to our environment.

By 10 P.M. almost everyone has returned to the vehicles, exhausted, thirsty and ready to depart. Ted, however, is nowhere to be seen. Perhaps he is lost, but I know from experience that he has trouble giving up when there is interesting game afoot. I decide to try to find him at the most distant and largest dunes, a brisk 15-minute walk. In time I see a light on the slip face of a dune. There is Ted, eagerly collecting a gecko species new to our expedition.

Geckos are lizards; most are nocturnal. Many can be easily seen with a flashlight: their eyes look like double stars. We stroll back along the dune crests, light beams directed below, sliding down the sand to catch more geckos. Iran's ground-dwelling geckos are slow compared with most lizards. Many seem to enjoy lazy lives sitting near their burrow entrances, waiting for insects to meander by.

Early the next morning I return to the still-steamy dunes with Jim and Sheda, who hurry off to check their traps. I chase lizards with Hadi Fahini, a bright Iranian undergraduate. In this pursuit, most herpetologists use a fishing pole for which the line has been cut short, its tip fashioned into a noose. You see the quarry from a distance, lower your pole so the noose falls around its neck, and jerk it tight. This to me lacks the hunting satisfaction of the hands-on approach. For that, a tandem method I use with Hadi is most effective. Moving slowly, the designated catcher approaches the beast obliquely and, if possible, out of view behind vegetation so as not to startle it, while a companion advances in clear view but at such an angle that the lizard is likely to make a dash toward the catcher. Repeat as necessary, changing roles as the situation dictates, until one of you is close enough for the final lunge. In one hour, Hadi and I have each captured three specimens of a slim gray species.

Sheda runs by in a panic: her traps have been stolen! There ensues a frantic exchange with our security force. Unbeknownst to her, Sheda had placed her trapline near a village. Later the traps mysteriously reappear.

More traps are stolen a week later.

Sheda Morshed and Jim Patton watch hedgehogs explore a room at an agriculture station.

This time Hooshang Ziaie, Iran's premier mammalogist, soon returns them with a smile. He has climbed to a nearby village and told them we have lost some traps. "That is not important, since the food in them is poisonous. Return them and I will give you the antidote." Built to catch rodents live, the traps had been baited with ordinary nuts. But Ziaie gives out a vitamin pill for each trap returned, a placebo cure for thievery.

Despite the waylaid traps, the day yields 35 gerbils, hamsters and rats. Beneath a shady willow, the Iranians and Americans dispatch them and prepare them for study, skinning each and stuffing the pelts with cotton. Sheda recounts dissecting a fish from the Caspian Sea as a child while her sister watched in disgust. "You were born to do this, my lady," Jim says. "You just didn't know it."

For biologists like Ted, Bob and Jim, a lizard or rat in the hand can be a marvel to be admired in its own right, but more than that it represents a clue with which to unravel the mysteries of its species. When Ted and Bob look at a map of Asia, they see geological history, the complex folding of tectonic plates that drop valleys and lift mountains while creating deserts and seas. Lizard populations shift across this changing landscape, and this evolutionary history can be traced from the variations in their DNA. Part of Ted and Bob's work is to freeze, in liquid nitrogen, tissues from animals they collect, for later genetic analysis at the Washington University laboratory in St. Louis, Missouri, where Bob works.

Jim usually works in the Amazon Basin, a very different landscape. This floodplain looks simpler than the varied terrain of Asia, but the Amazon harbors more species. It is tropical, and the many rivers can block dispersal, allowing new species to form on each bank. What Jim discovered is that for his beloved rodents, the bank matters less than the location along the river, upstream or down. Ranges of similar species tend to begin and end together at the same spots along both sides of a river. Again the mystery was solved through sleuthing geological history: Jim and colleague Maria da Silva noticed these spots correspond to ancient ridges that had eroded away. These had once split the populations.

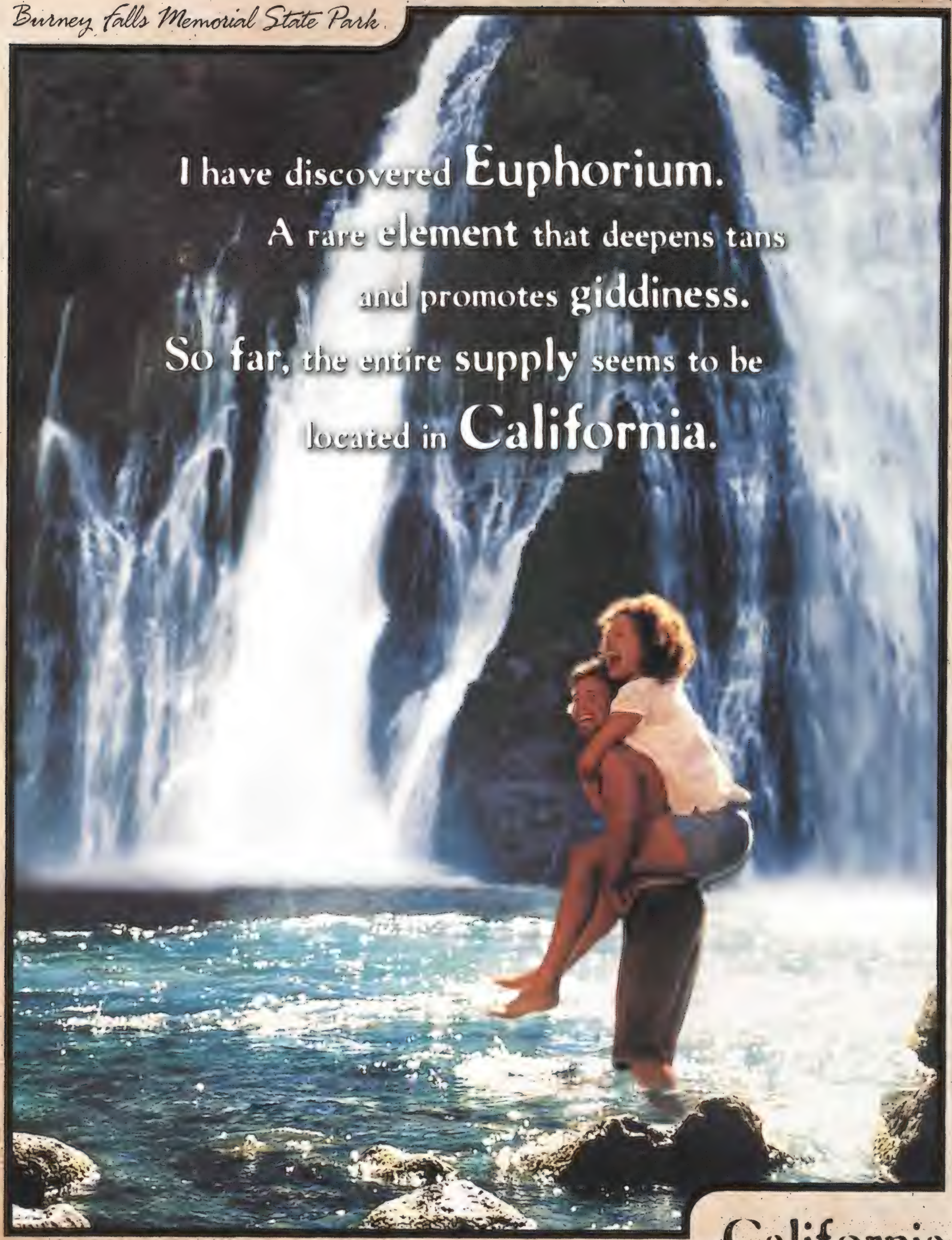
"It's never too early for a Delster!" comes our group's traditional morning cry from the kitchen. Bob is tipping back a bottle of a nonalcoholic beverage that is the closest thing to beer available in Iran. Alcohol is not legal in this Muslim country, but (although we never did it) it seems widely known that one need only add yeast and sugar to an open Delster, seal the bottle, and wait a week to concoct the real thing.

From our guest house at the agricultural station in Kerman, Bob and I make our way to the dining room at 5 A.M. to join the other American and Iranian scientists eating omelettes, cheese and delicious Iranian flatbread. Ted has opened a jar of Skippy—keeping up his tradition of introducing locals to peanut butter. I first met Ted and Jim in Vietnam two years before, and there Ted's Skippy had not gone over well. (Indeed, the Vietnamese may have found American devotion to peanut butter every bit as curious as our policy of wearing panty hose to ward off leeches.)

We are up early this morning to begin a notable leg of our journey. The plan is to pass through the Dasht-e Lut (one of the great deserts of the Middle East) and, continuing on, to go right by the site where Pakistan, Afghanistan and Iran intersect, to reach a corner of Iran where Bob and Ted are eager to collect. "It's the easternmost extension of an important geographical region called the Sistan Basin," Bob says. "We'll find some unique animals that otherwise only exist in Afghanistan." But, as every morning, our departure is delayed about an hour. Jim groans. "Sure, maybe there are some risks. But I'd rather die with a rat in my hand, happy, than just sittin' around waiting all the time."

Eventually what should have been a 7-hour ride is drawn out to 18 hours, as at various times we run out of gas, stop for supplies, deal with flat tires and have film confiscated by police for photographing what turn out to be dumped drums of benzene. The Lut Desert is bleak and flanked by distant gray hills. By 3 P.M. we

Burney Falls Memorial State Park.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Here are just a few of the cast of characters the biologists encountered on their excellent adventure. Denizens of the desert are (clockwise from far left): a miniature owl; a mouse-size rock hamster; a camouflaged grasshopper nymph; a four-inch gecko lizard; and a short-horned grasshopper.

reach the city of Zahedan, where people with more Mongoloid features than we have encountered before stare at us in frank fascination. It is dark by the time we near the Pakistan-Afghanistan border. We have to stop at crumbling buildings: the first of eight military checkpoints. After some negotiations, we're provided with a military vehicle. This is exchanged for another one at the next checkpoint some miles down the road, and so on over the next few hours. Each time, the escort is a Toyota pickup truck with a machine gun mounted on the flatbed, which is packed with armed troops.

The next day I stand only yards from Afghanistan on the grounds of Sistan-Baluchistan University's Agricultural Station, where we will spend a couple of nights. Across the border the earth is barren and unoccupied, except for some mud dwellings visible in the distance. Ted has bagged a snake given to him by a farmer. For once no guards have chosen to watch us. After the others move on, I splash into a stream that apparently marks the border and leap right out again, proud of having sneaked a moment in Afghanistan.

A day after our equally arduous return journey, Natasha Ananjeva—a Russian herpetologist who joins us for four weeks—learns from anxious messages from home that a kidnapping occurred along the route we have taken. Three Italians had been

abducted. Sheda tells us that such events are common. It has happened to her cousin. Invariably prisoners are fed well and treated kindly. Still, perhaps we should be taking our security more seriously.

Our escorts tell us the Italians were freed in exchange for Iran's release of 27 death-row drug smugglers, who were flown to Pakistan. A news report says the Italians were held in the mountains near Zahedan, where they played backgammon and ate kabob. We cannot help but notice that by the Italians' account, the kidnapping took place when they were passing the same spot we would have been passing at that moment if there had not been delays on our journey.

With so much bustle it is hard to meet ordinary Iranian citizens, but every time we do we are met with great kindness and an open curiosity about America. On one occasion three families on their weekly picnic together motion for us to join them. They insist I try a fragrant noodle soup called *ash-e reshte* and share some sweet plums and nectarines and then a smoke on a water pipe. At a sheepherding village a dozen boys chatter around me, turning stones to show me critters.

At other moments, however, friction runs high. Many nights I take an electric generator to the field, plugging in ultraviolet lights to attract insects. Whenever possible I stay up all night to observe the comings and goings of

species or, if too tired for that, awaken for a half-hour every 90 minutes to check their activity. At 9 o'clock one night a military vehicle roars up to my light. An officer insists that I move two miles away. Fuming, I tear down my equipment, heap it in my arms and, joining the troops in the back of the pickup truck, loop electric cord defiantly around the mounted machine gun and stare back at six stubbly faces as we bounce along.

The author, left, and Iranian scientist Hooshang Ziaie use a light to attract insects at night. The specimens are plucked from the air and popped into jars.

By the time I set up my light again it is 11:30. The troops have stayed, and with my colleagues in their sleeping bags, they find I am the sole entertainment. One guard becomes two, until all six stand in my work space, a Persian carpet thrown over the sand. In the hope that they will lose interest, I feign sleep by lying on my side, keeping my lower eye open to view the light. Behind me the voices do not stop. At 2 A.M. I see a two-inch sun spider, an ugly creature related to scorpions that moves like cotton fluff in the wind. Before I can respond, a boot drops and crushes it. I am on my feet instantly. Without missing a beat I find myself in a screaming match, nose to nose with the officer. It is dangerous, he indicates. No it's not, I reply. I'm here to study such things. Very dangerous, he warns, glaring. No, I respond. He and all but my first two guards walk away, muttering to themselves. I wonder if I've gone too far, and where exactly danger does lie.

But the remaining guards now seem cheerful. We strike up a conversation, they with 20 words of my language between them, I with fewer of theirs. Another sun spider appears as a horrifying blur of motion. We chase it back and forth over the dunes. It shifts course at dazzling speed as we throw ourselves at it again and again. For ten long minutes it gives no sign of tiring, as if this pace were normal. Finally I force it into a bottle and other guards return to admire our fierce-looking prize. They now help me on my hourly rounds of the area. We pass Ted, Jim, Bob, Sheda and the others, asleep under a broad sky. I wonder at the absurdity of it all, this Midwestern boy chasing strange-looking arthropods with Muslim militia.

They manage to convey how one can't see stars in Tehran because of pollution. Same for American cities, I tell them. "Dinosaurs in your country?" No, I say, imagining they have seen a bootleg copy of *Jurassic Park*. "United States is dinosaur?" I hope not, I say, amused by this clearly unintended commentary. At 5:30 A.M., they climb back into the Toyota and roar away, giving me a playful salute just as my friends begin to stir with the dawn's early light.

Ted and I are now back in Berkeley. We have new species, data to write up. We are also organizing our next expeditions. Ted is in e-mail contact with someone in Afghanistan who seems excited about having an American visitor. Doubtless, Ted is already dreaming of lizards at the opposite end of the Sistan Basin.

If the current round of fighting in Afghanistan ends in this computer penpal's favor, Ted says he'll go. I don't have the heart to tell him that I have already been there.

Mark W. Moffett is writing a book about Western ideas of adventure and discovery. He wrote about vines in September 1993.

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A FURY FROM HELL

BY CONSTANCE BOND

AS UNDERWATER ARCHAEOLOGISTS PULL ARTIFACTS FROM WHAT MAY BE THE WRECK OF BLACKBEARD'S FLAGSHIP, HISTORIANS RAISE NEW QUESTIONS ABOUT THE LEGENDARY PIRATE

IT'S LATE MAY 1718, AND THE GOOD PEOPLE OF CHARLES TOWN, IN the colony of South Carolina, are in an uproar. The nearly 20,000 residents of this fledgling, walled city have had their hands full fighting with the Yamasee, Creek and other Indian tribes angered by the spread of rice plantations. And now, this.

Moored just outside the entrance to their harbor and blocking all traffic is a flotilla of four vessels. Three of them are sloops of modest size. But the fourth, the *Queen Anne's Revenge*, is a true pirate ship. More than 80 feet long, the square-rigger sports three tall masts, a raised quarterdeck at its stern, dozens of cannon ominously poking through its gunports and a deck swarming with some 150 crew. On the deck, a large man with a long black beard curses and rages. Edward Teach, nick-

OR WAS HE?

A 1736 engraving reveals Blackbeard's reputed trick of hiding lighted fuses under his hat.

named Blackbeard, is holding the city hostage. He and his company of some 400 men have waylaid and plundered several ships, capturing the crews and passengers, including some of Charles Town's most prominent citizens. His demand? Deliver a chest of medicine, or he will deliver the prisoners' heads and burn the vessels.

Shortly after capturing them, the pirates herd the prisoners off the *Queen Anne's Revenge* and shut them in darkness in the hold of a captured vessel. Huddled together, the captives listen in terror for the pirates' footfalls on the wooden deck above, certain that their return will signal death by cutlass, pistol or a toss into the drink.

But it doesn't happen. Within hours, the hatches are opened and the prisoners pulled back on deck. Then, in a manner more befitting a CEO holding an impromptu business meeting than a bloodthirsty madman, Teach calls a delegation of the prisoners into his own cabin on the *Queen Anne's Revenge*. Calmly, he explains that they were taken off the ship so that the pirates could hold a "general council" to decide on their next move.

It is an odd departure from the anticipated script of mayhem and murder. This episode and others have raised questions about the character of Blackbeard. Blackbeard may not have been the evil cutthroat of popular imagination. The reality is far more complex. He was a master of psychological warfare and intimidation, a charismatic and dramatic personality, a savvy outlaw and, until the very end, perhaps not even a murderer at all. It appears that coastal North Carolinians may have known this all along, celebrating him as a folk hero who stuck a hot poker in the eye of their imperious British overlord.

Within a week, the medicine chest is duly delivered and the prisoners are returned, unharmed except for their pride. The pirates strip them of their fancy duds, and they are "sent ashore almost naked," as South Carolina's governor later complains in an indignant letter to London. Teach's flotilla triumphantly weighs anchor and heads north. But within only a week, the *Queen Anne's Revenge* lies aground on a sandbar near the entrance to present-day Beaufort Inlet in North Carolina. And within six months, in Ocracoke Inlet, just south of Cape Hatteras, Teach's severed head hangs unceremoniously from the bowsprit of a sloop commanded by British lieutenant Robert Maynard, sent after him into North Carolina waters by the governor of the colony of Virginia.

Everyone who was anyone knew about the villainous exploits of Blackbeard and his crew, especially the tobacco plantation owners and British colonial operatives around Williamsburg, Virginia, and their rice-growing counterparts in Charles Town to the south. Blackbeard's death must have been welcome news to the British

investors back in Bristol and London, who were fed up with harassment of their extremely lucrative three-point trade: guns, textiles and other relatively cheap goods exchanged in Africa for slaves, who were then sold to the Colonies and the islands of the West Indies for sugar, rum, tobacco, rice and other commodities.

Blackbeard's demise was little celebrated, however, among the sparse, hardscrabble population of white settlers in the watery frontier wedged between Virginia and South Carolina, an area that one day would become the state of North Carolina. Running along its entire coast is a ribbon of barrier islands cut through by squirrelly, constantly shifting inlets. With no deepwater port, this was a

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Blackbeard's successes so swelled his ranks that he ran the *Queen Anne's Revenge* aground outside Beaufort Inlet in June 1718.

RICHARD SCHLECHT

backwater economy. Most of these folks were fishermen, farmers and, on the barrier islands, shipwreck scavengers. It didn't bother them that the planters of Virginia and South Carolina looked down on them.

As the noose tightened on pirates in the other Colonies, it remained loose in North Carolina. Edward Teach was quite at home behind its barrier islands, slipping behind Ocracoke Island to hole up (navigation charts today still identify this stretch as "Teaches Hole") and crossing shallow Pamlico Sound to Bath, the only town of any size in the area. There, he sold coveted goods at well below the British-tax-inflated prices and hobnobbed with residents, perhaps even the governor himself. According to some sources, he married a local woman. In short, Edward Teach became entwined with the region's history.

After his death, his reputation continued to grow. In Boston, a teenage Ben Franklin wrote a "sailor's song, on the taking of Teach (or Blackbeard) the pirate," copies of which he hawked in the streets. Letters from Virginia describing the bloody battle at Ocracoke between Maynard and Teach were published in London papers. Just six years later, in 1724, a massive tome entitled *A General History of the Robberies and Murders of the Most Notorious Pyrates* was published in London, detailing the exploits of Teach and his contemporaries. Already, fact was overlapped with myth: Blackbeard tucked slow-burning fuses under his hat

Blackbeard found haven in the scrub forests of Springer's Point (inset) and the sinuous waterways surrounding Ocracoke Island.

when approaching mariners at night, giving him the appearance of the devil (possible); Blackbeard had 14 wives (less likely); Blackbeard's headless body swam several times around his sloop at Ocracoke Inlet before sinking (not likely). And what of Blackbeard's legendary flagship?

It now appears that the wreck of the *Queen Anne's Revenge* may be Blackbeard's payback to the slightly off-the-charts colony that gave him shelter. She—or a ship like her—was discovered in shallow water just outside Beaufort Inlet in November 1996 by Mike Daniel, director of field operations for a small outfit called Intersal, Inc., which is devoted to locating and excavating historic shipwrecks. Intersal's president, Phil Masters, had originally intended to search for the remains of a gold-laden Spanish ship, but he knew that Blackbeard's ship was out there because of conversations he had with archaeologist David Moore, an authority on Edward Teach.

After investigating a 30-by-20-foot pile of ballast stones, barrel hoops and what looked like giant, shell-encrusted pick-up-sticks in 20 feet of water, Daniel called Moore. "Dave," he said, "I'm sitting on a whole lot of cannon; I think I've found your ship."

If there's poetic justice in the world, the discovery of what may be Blackbeard's flagship in the waters of coastal North Carolina is it. It's not a question of treasure. According to eyewitnesses, Teach purposely beached the ship and stranded some of his crew—in effect, downsizing his cumbersome pirate company—and removed everything of value. The discovery of this wreck would make no one a millionaire. Instead, the wreck would represent a remarkable cultural treasure, a collection of artifacts from the pirate who many in North Carolina regard as an honorary ancestor.

Edward Teach was probably born in Britain. According to the *General History*, he cut his seafaring teeth aboard British privateers out of Jamaica during Queen Anne's War (1702-13). Privateers were just this side of legal; in essence, they had permission from Britain to take French and Spanish ships and keep a percentage of what they found. This arrangement changed in 1713 when the major European powers declared peace, throwing more than a thousand privateers out of work.

So Teach and hundreds of others became outlaws. Teach sailed for a while with his mentor, Benjamin Hornigold. Like other pirates, they followed a snowbird routine. In the spring they'd head north in their small, maneuverable sloops and harass merchant ships, laden with cocoa, cordwood, sugar and rum if they were lucky, along the Delaware Capes or the lower Chesapeake. In the fall, they sailed back south to the islands. Hornigold and Teach were seen in October 1717 off the Delaware Capes; the following month they captured a ship near St. Vincent

KELLY CULPEPPER (2)

in the Caribbean. Teach claimed the ship and renamed her the *Queen Anne's Revenge*. With her, Blackbeard became a wild success, taking some 25 prizes.

For rest and relaxation, Teach headed to Nassau on the island of New Providence in the Bahamas. Because New Providence was a proprietary colony, which meant it was not directly under the king's control, the pirates were not bothered by the law and could enjoy the rum and women in its waterfront taverns. In spring 1718, his bloated flotilla "fished" the old Spanish wrecks off the Bahamas. Then, with the cannon of the *Queen Anne's Revenge* loaded and ready for action, he headed north to Charles Town.

So how certain are archaeologists that the cannon-laden wreck outside Beaufort Inlet is the *Queen Anne's Revenge*, centerpiece of the flotilla that terrorized Charles Town? The cannon provide strong circumstantial evidence. Historical records in France indicate that the *Queen Anne's Revenge* was originally a slave ship out of Nantes named the *Concorde*; she was bound for Martinique when Teach took her. Teach renamed her and added more cannon, bringing her complement to about three dozen. So far, 21 cannon have been located in the wreck; no other 18th-century ship so heavily armed is known to have sunk in Beaufort Inlet.

Although not enough of the hull has been found to determine the size and type of ship, three seasons of limited trench excavations have yielded other valuable clues. There are pewter plates with the marks of a London manufacturer known to have been active for several decades beginning in 1693. A foot-high bell, possibly plundered from another ship, bears an inscription dating it to 1709. Other items are nearly identical to artifacts recently brought up from the *Whydah*, a slave ship that sank in 1717 off the coast of Cape Cod several weeks after having been taken by the pirate Sam Bellamy. Among them are a pewter syringe, a sea-serpent-shaped side plate for a blunderbuss or musket, and cannon aprons (movable metal plates that covered the touchhole of the loaded cannon).

A team of scientists, most of them college professors from North Carolina and Virginia, are examining everything from the chemical "fingerprints" of the shipwreck's ballast stones (they hope to match them with stones found at ports where Blackbeard's ship stopped) to the contents of the syringe (the scientists found traces of mercury, which was administered into the urethras of the unfortunate victims of venereal diseases—a cure that could itself kill the patient). Although funds are not yet available for full-scale excavation and conservation, there is a growing sense of urgency: the hydrologists believe that for most of its existence the wreck has been buried under sand—protecting it from destructive organisms and strong currents—but large portions of it have lately been uncovered by

some natural events, perhaps the recent series of hurricanes.

While it hasn't been proven definitively—yet—that this wreck is indeed the *Queen Anne's Revenge*, that hasn't held back the town of Beaufort, which last year had a huge portrait of Blackbeard, slow-burning fuses and all, painted on its sky-blue water tower. And it hasn't dampened the enthusiasm of the small army of underwater archaeologists, historians, conservators, scientists, divers, dive-boat captains and volunteers who have been assembled under the umbrella of the QAR Project. At the project's core are the staff members of North Carolina's Underwater Archaeology Unit, or UAU. This crew of a half-dozen resourceful people (all of them divers, from the office manager to the director) are experienced hands, since they're responsible for documenting and protecting the state's 5,000 historically recorded shipwrecks.

Members of North Carolina's Underwater Archaeology Unit pull a cannon from what may be the long-lost wreck of Blackbeard's flagship.

But this wreck is over the top—even if it isn't Blackbeard's ship, it's still the oldest shipwreck ever investigated in the state. Inside the QAR headquarters, a former scallop-processing plant around the bend from the idyllic Beaufort waterfront, two cannon, hooked up to Sears battery chargers, recline in their own tubs of water like patients on life support. They're undergoing a five-year-long electrolytic bath to free them of salts. Nearby shelves brim with smaller objects: pewter plates, one of them with a hole that looks suspiciously like a bullet hole; plastic bags filled with ballast stones; a set of brass dividers, cleaned up by the conservators, that Teach himself may have held in his hands. Hundreds of objects, many in their own little baths, fill another UAU conservation lab near Wilmington, North Carolina.

Not surprisingly, the QAR team has recently been conducting magnetometer surveys at the wreck site—searching for more cannon and other ferrous objects buried in the sand—rather than bringing up more artifacts. The site is 20 minutes away by boat. That's ten scenic minutes in protected water—past the large shrimpers tied up along the wharf, and the low rooftops of Beaufort—and ten minutes of rock-and-roll through the inlet itself, that geographic hourglass where the shallow but expansive back bay shakes hands with the ocean through a narrow opening.

North Carolina's barrier islands are only several hundred yards wide in places, and the inlets that cut through them enable careful boaters to go back and forth between the ocean and the sheltered back bays, which lie between the barrier islands and the mainland. This broken ribbon of sand, called the Outer Banks, reaches down from the Virginia line, far out to sea at Cape Hatteras, with its deadly offshore shoals, and then arcs southwest back to Cape Lookout; Ocracoke Island is along this stretch. Another arc of sand, where Beaufort Inlet is found, follows more closely along the coast from Cape Lookout southwest to Cape Fear. Throw in tides, wind and a shifting geography, and it's no wonder pirates came here. North Carolina's barrier islands are equivalent to the labyrinthine slot canyons of the Southwest into which a different sort of outlaw often holed up.

Getting through any of the inlets, including Beaufort Inlet, can be quite a ride. Julep Gillman-Bryan, captain of the UAU's 24-foot dive boat, the *Snap Dragon*, routinely has to wedge herself in, feet hard against the bulkhead, backside pressed against the seat, as the boat climbs and falls with a shudder through five-foot swells. Imagining pirates negotiating this hostile environment with no engine, hundreds of yards of sailcloth and a 200-ton vessel gives one an appreciation for their seamanship.

For the better part of a week in June, the *Snap Dragon* is one of four dive boats that make this run as the magnetometer surveys get under way. On the days when the water at the site isn't too rough, the boats tie up at moorings and the divers get to work. In the hazy distance to the north, Blackbeard watches from the water tower, the tallest landmark on the low-lying shoreline. Some divers collect ballast stones, others sketch. David Moore, coordinator of the maritime archaeology program at the North Carolina Maritime Museum in Beaufort, is on loan to the QAR Project. He will spend the day underwater in front of a tangle of ship's rigging, drawing a detail of it. A big bear of a man, he holds a waterproof sketching slate against his

JIM BOUNDS/NEWS & OBSERVER

Booty from the wreck: archaeologist David Moore displays the ship's bell; Wayne Lusardi preps a recovered cannon; (clockwise) bell, pewter plates, cannon ball, blunderbuss barrel, sidepiece decoration, syringe, pivot mount, cannon apron, sounding weight.

KELLY CULPEPPER (3)

chest as he gently falls backward off the boat with a splash.

In the water, two divers with a magnetometer sensor are swimming in a grid over the shipwreck, stopping every two-and-a-half feet to record a reading. The sensor, which resembles a stainless steel pipe duct-taped to an upside-down PVC patio table, will yield more than 200 readings over the site, which will later be crunched on the computer. These readings may yield the location of more cannon. During the next excavation session, in October, they'll survey a larger area, hoping to find more buried cannon; or, even better, a ship's bell bearing the name "Concorde." The team members are confident that they'll find the proof they are seeking.

As the divers continue to piece together the shipwreck puzzle, the historians have been doing the same thing with the historical record. One of the divers on the QAR team—also a Tarheel—is retired historian Lindley Butler. "What's great about this shipwreck and that of the *Whydah* is that they're a dose of reality amid all the myth," Butler says. "Everybody has the image of pirates from the Errol Flynn movies, but Teach and the other pirates of this era didn't want to fire the cannon. They tried to avoid sea battles. Teach did all he could to intimidate—he cultivated his image, and in the end, it did him in." Typically, in taking a ship, he would fire a cannon across the bow of the intended prize—a warning shot—and then hoist the flag. Usually that was enough. One look at the dreaded Blackbeard, his rough-and-ready crew, cannon poking out from every port, and the black flag running up the mast could scare even the most courageous merchant captain into immediate submission. Those fools who did resist drew more cannon fire, as well as hand grenades fashioned from bottles filled with powder, shot and lead.

A couple of warning shots, a hoisted flag, a lot of shouting and, finally, surrender, says Moore, is basically how Teach took the *Concorde*. We know this because in 1719 the captain of the *Concorde* returned to France and gave a detailed report about the engagement. He also said that Teach had given him a sloop so he could reload his cargo of slaves and continue on his journey.

As with the hostages in Charles Town Harbor, it was not so bad an encounter that the captain didn't live to tell about it. Which brings up the character issue. Butler, Moore and other historians from North Carolina have a take on Blackbeard that's quite different from the one shaped back then by, well, Teach himself and the British.

Beaufort Inlet and other breaks between North Carolina's barrier islands gave Blackbeard access to shallow and protected back bays.

Teach's motive: the worse he looked, the better it was for business. The British motive: the worse the pirates looked, the more they could justify hanging them. The North Carolinians have their own collective memory of Blackbeard—and for all the evil things that were said about him, they recall a kinder, gentler pirate. Drawing on local legend, for instance, North Carolina former law professor Robert E. Lee wrote of Teach's dealings with women that "few pirates treated women or girls with greater respect. . . . He would not let a girl serve him a drink; he preferred to serve the drink to the girl." This is a far cry from the story that circulated in Teach's time, and was repeated for posterity in the *General History*—that Teach prostituted his wife in North Carolina to the other members of his crew.

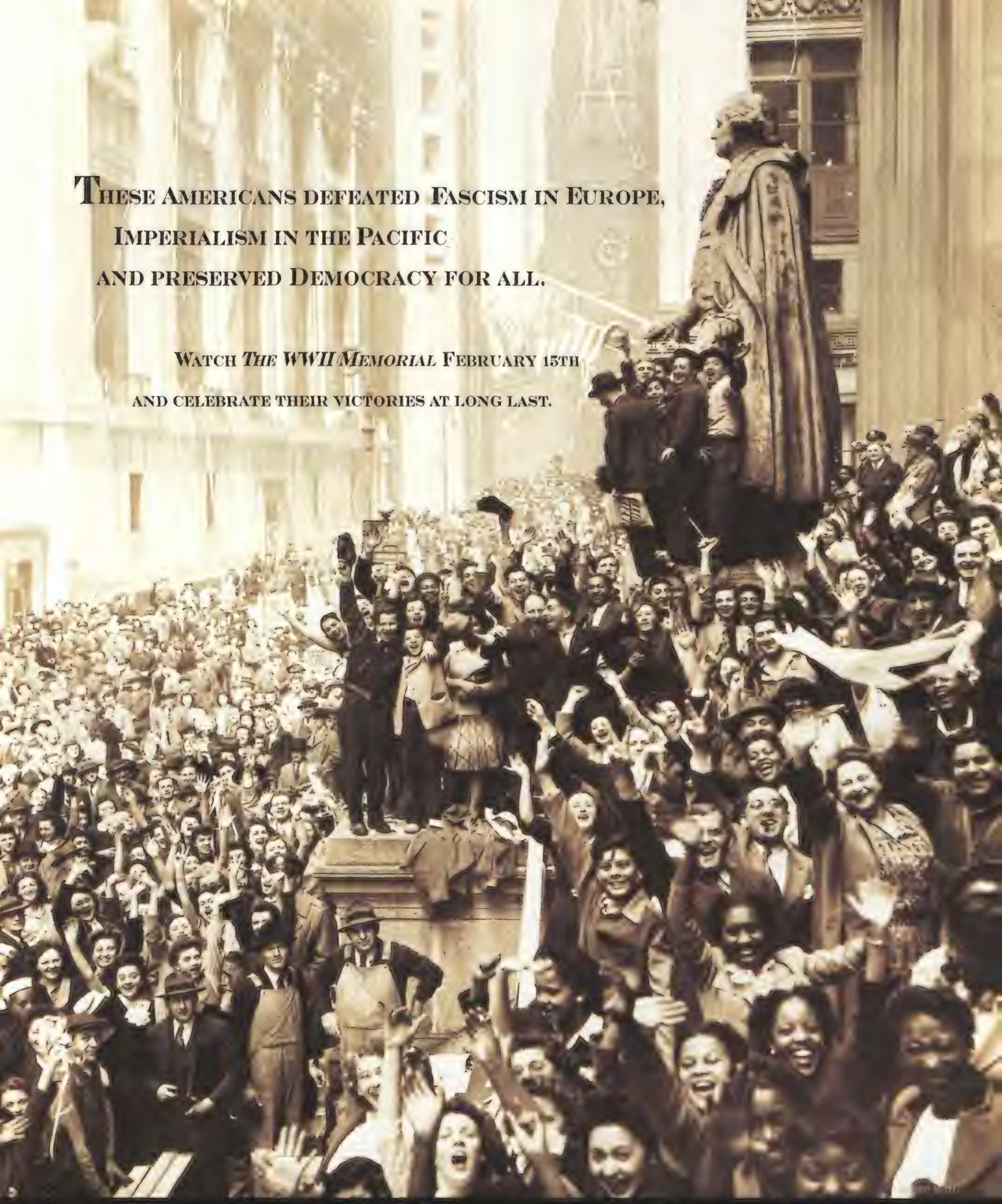
In search of the real Teach, Moore has gone through all the available historical records. Although they often contradict each other—everybody had an agenda—there are surprisingly many of them. In addition to the *General History*, they include trial testimony of captured pirates who sailed with Blackbeard; eyewitness accounts of captains whose ships he captured; letters written to London by exasperated British officials; and logs of British patrol ships sailing out of Virginia.

A surprising discovery concerns a rip-roaring battle, chronicled by the *General History*, in which Teach supposedly routed a 28-gun British ship, the *Scarborough*, shortly after acquiring the *Queen Anne's Revenge*. The battle seems never to have occurred. Moore went through the ship's log in the British Public Record Office and found no mention of this incident. Even more surprising is another Moore observation: "Blackbeard cultivated a 'demon from hell' look, but we have found no evidence that he killed a man until the battle with Lieutenant Maynard."

This "demon from hell" look is well detailed in the *General History*. Its description, some of which is corroborated by eyewitness accounts of the time, outdoes anything that Hollywood could invent: " . . . our Heroe, Captain Teach, assumed the Cognomen of Black-beard, from that large Quantity of Hair, which, like a frightful Meteor, covered his whole Face. . . . This Beard was black, which he suffered to grow of an extravagant Length . . . he was accustomed to twist it with Ribbons, in small Tails . . . and turn them about his Ears: In Time of Action, he wore a Sling over his Shoulders, with three Brace of Pistols, hanging in Holsters like Bandaliers; and stuck lighted Matches under his Hat, which appearing on each Side of his Face, his Eyes naturally looking fierce and wild, made him altogether such a Figure, that Imagination cannot form an Idea of a Fury, from Hell, to look more frightful." That, and 40 cannon, would be pretty intimidating.

While he provoked feelings of fear and terror among the ships' crews he encountered, he was greeted with a different sort of emotion across the Atlantic. "Not only were the pirates taking property," says Lindley Butler; "they were an affront to the hierarchical, class-based social structure in Britain. I think that burned them back in England as much as the property taking." Butler is referring to the way the pirates organized themselves, which was radical for its time. They elected their captain, quartermaster and other ship's officers; conducted "general consultations" on itinerary and strategy (such as the meeting held aboard the *Queen Anne's Revenge* in Charles Town Harbor), in which all members of the crew voted; worked out an equitable division of prizes (for example, one share for all but the captain, who got two). This pirate code was written up in articles that each crew member signed upon joining the company. In the articles of pirate Bartholomew Roberts' crew, for example, every detail of shipboard life was cov-

KELLY CULPEPPER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Beneath the raised sword of a British sailor, the pirate captain battles for his life in Howard Pyle's *Blackbeard's Last Fight.*

ered; there were provisions for the settlement of disputes ("No striking one another on board, but every man's quarrels to be ended on shore, at sword and pistol"); for gambling ("No person to game at cards or dice for money"); for wounds suffered in battle ("If . . . any man should lose a limb, or become a cripple . . . he was to have 800 dollars"). "Unlike the Royal Navy, the merchant navy, or indeed any other institutions in the seventeenth and eighteenth centuries," notes British historian David Cordingly in his book *Under the Black Flag*, "the pirate communities were . . . democracies."

Yet another affront to the British may have been that some pirate ships, perhaps including Teach's, included blacks as members of the company. During the battle at Ocracoke Inlet, Teach told a man named Caesar, one of several blacks on board, that if it looked like Maynard was going to win, he should torch the sloop. It is unlikely, say Butler and Moore, that Teach would have given that task to anyone but a full crew member.

Fifteen pirates were rounded up and taken by Lieutenant Maynard to Williamsburg, Virginia, and tried, but unfortunately the trial transcript was lost, most probably during the Civil War. It is known, however, that in Williamsburg the decision had to be made whether to treat the five black defendants as slaves or to try them as pirates. Pirates it was. In the end, 13 men were convicted and hung.

Of course, Teach himself didn't survive to be tried; he died on the windless early morning of November 21, 1718, after Maynard's two sloops slipped into Ocracoke Inlet, where Teach and his crew were bleary-eyed from a night of carousing. If, indeed, Teach never killed a man prior to this battle—an intriguing thought, although it will never be known for sure—he made up for it here.

Teach had roughly 20 men; Maynard had three times that. But while Maynard had only small arms, cutlasses and pistols, Teach had nine mounted guns on his sloop, the *Adventure*. When Teach and his crew headed the *Adventure* into a winding channel, Maynard's sloops ran aground. As Maynard's men worked frantically to free them, Teach's voice bellowed across the water. "At our first salutation," Maynard later reported, "he drank Damnation to me and my Men, whom he stil'd Cowardly Puppies." Once afloat, Maynard's sloops moved toward the *Adventure*. Maynard was no fool; when Teach's crew fired a broadside of nails and iron scraps from the mounted guns, Maynard had his men hide below to trick him, causing Teach to believe they'd been killed. Then, when Teach's crew pulled alongside and boarded, Maynard's men stormed the deck.

Teach and Maynard engaged in brutal face-to-face combat, swinging their swords as men dropped around them, coating the deck with blood. Maynard's sword bent upon hitting Teach's cartridge box; the lieutenant then shot Teach with his pistol. But the tall pirate captain kept fighting. At this point, as reported in the *Boston News Letter* in 1719, in the most complete account of the battle, one of Maynard's men jumped in to assist, slashing Teach's neck with his sword. "Well done, lad," Teach said to him. With that, Maynard's man swung the sword through Teach's neck, cutting off his head. When Blackbeard fell, he had five gunshots and 20 cuts in his body. Some 20 lay dead.

"Here was an End of that courageous Brute, who might have pass'd in the World for a Heroe, had he been employ'd in a good Cause," says the *General History*. "His Destruction, which was of such Consequence to the Plantations, was entirely owing to the Conduct and Bravery of Lieutenant Maynard and his Men." Well, they're not so sure about that in North Carolina's low country; back then, the fortunes of Britain's plantations meant nothing to them. And today, aboard boats passing by a certain shipwreck just outside Beaufort Inlet, more than one bottle of rum has been raised in a toast of damnation to that cowardly puppy Lieut. Robert Maynard.

Contributing editor Constance Bond wrote in 1998 about Vincent van Gogh, posters, and photographs from the gold rush.

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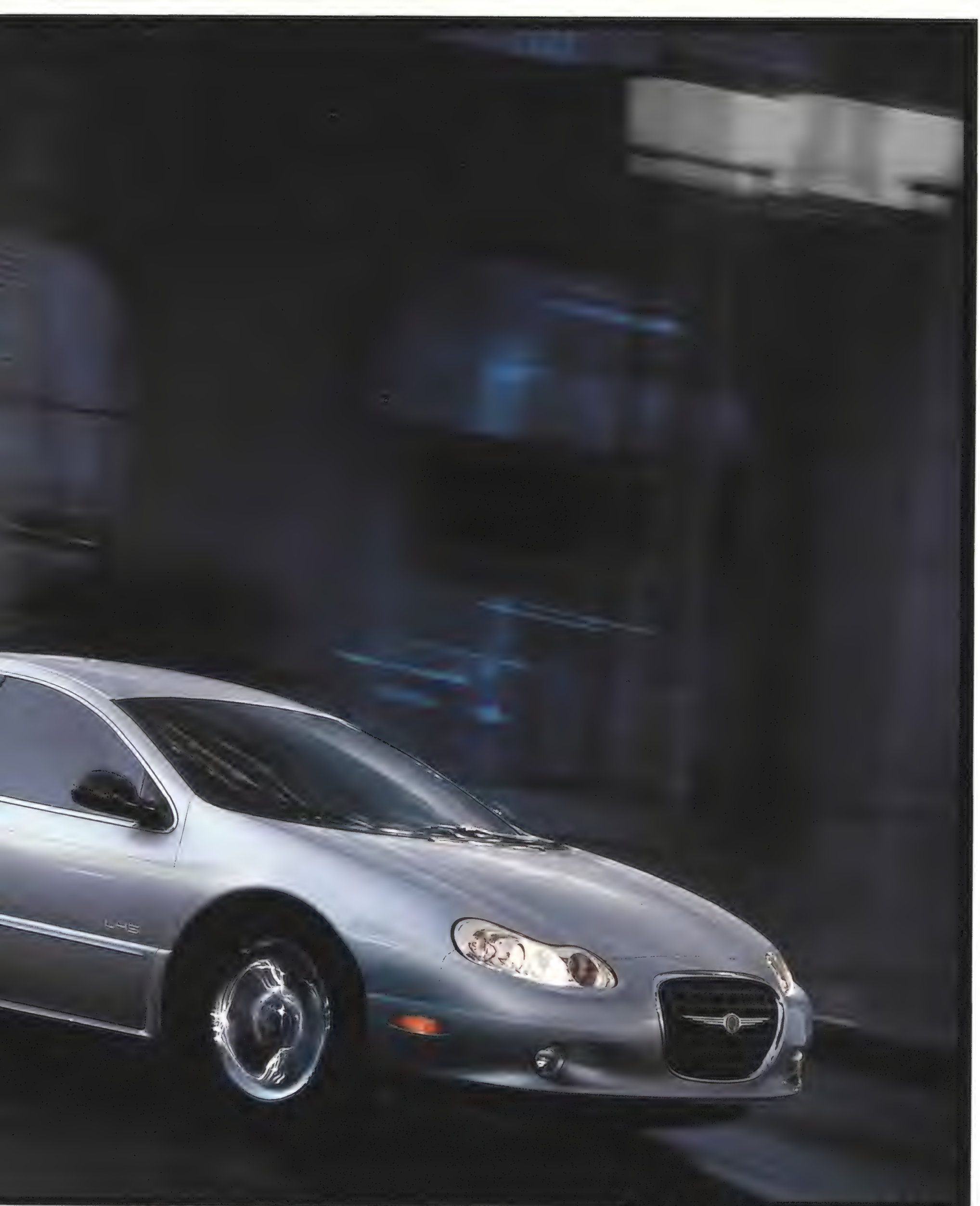

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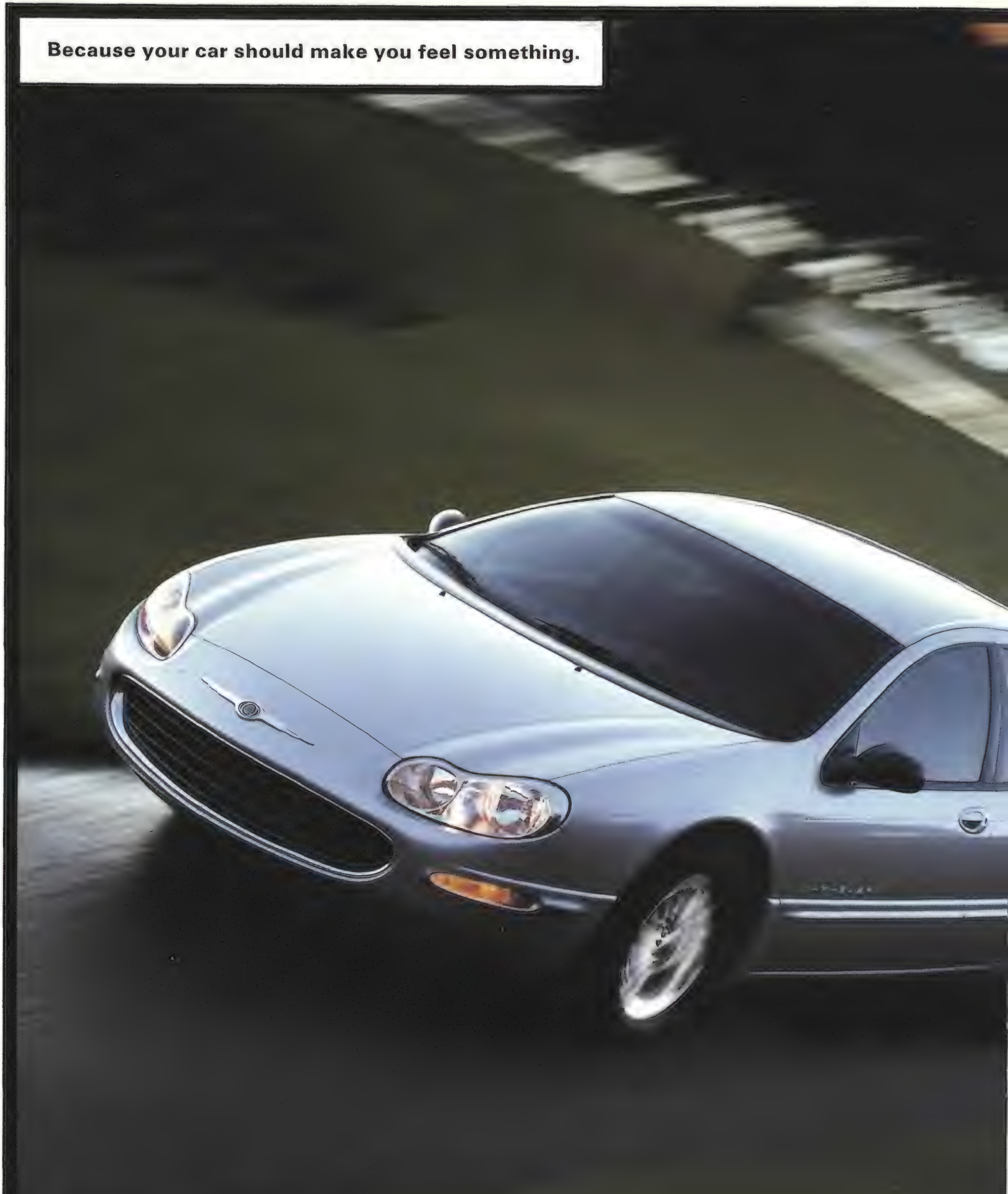

It has four doors and a more-than-spacious interior. That's where its similarity to other full-size sedans ends. Chrysler Concorde LXi was creat
desire for something out of the ordinary. With inspired cab-forward design, low-speed traction control and a suspension tuned to enhance

d for those whose need for everyday transportation hasn't dulled their
de and agility, Concorde takes the daily commute in a different direction.
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Because the call of the open road is still there to be heard.

We invented the minivan for people who were tired of trading carlike handling for room. That uncompromising character finds its ultimate
With the most available luxury appointments, and 16 years of design and engineering leadership, it does something no other minivan can:

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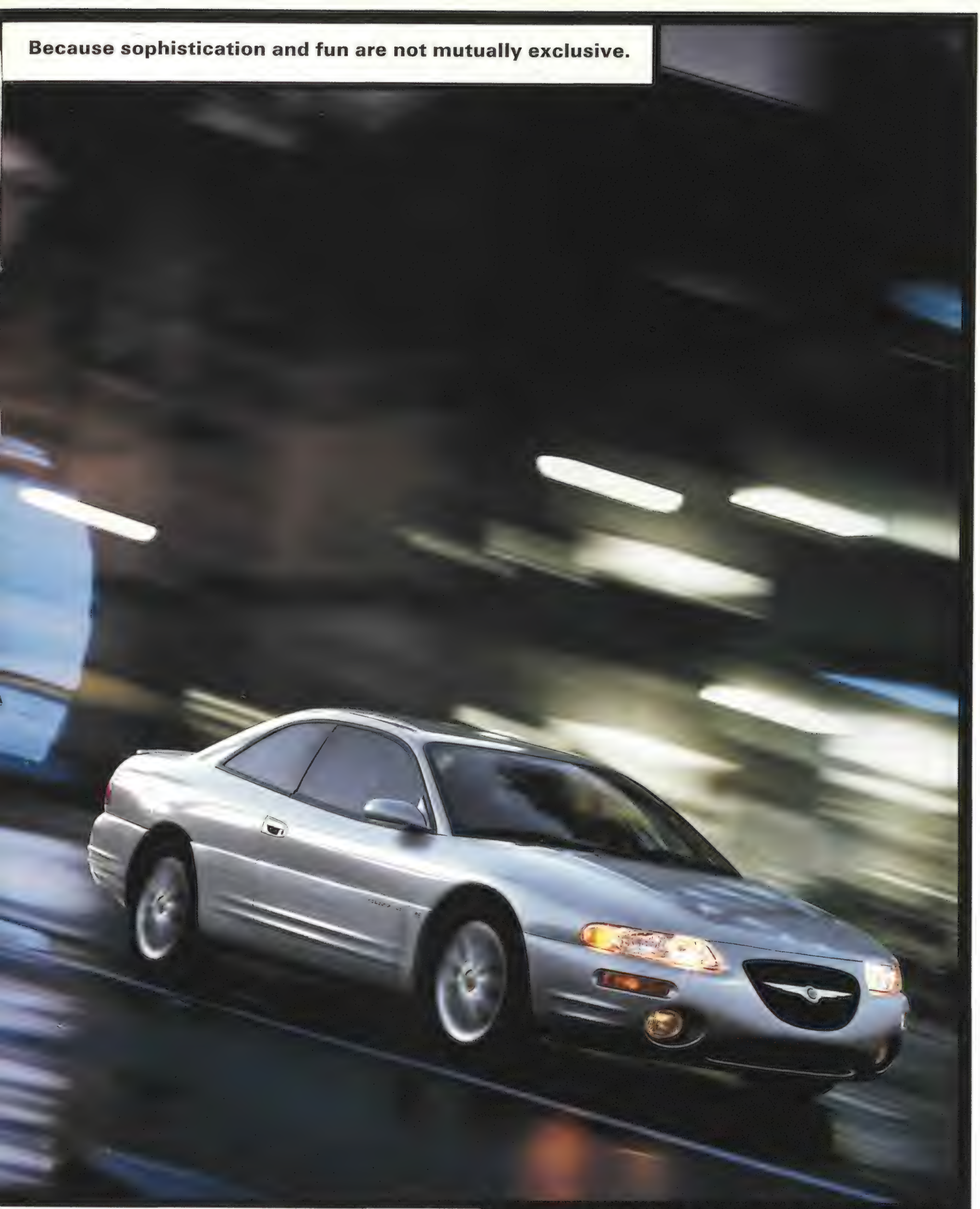
Because you can be simultaneously protected and completely free.

While the sun may not shine 365 days a year, Sebring Convertible does. Because it was engineered from its tight-sealing, double-layer top an altogether different sort of driving exhilaration: Its refined looks conceal a multi-valve V6 and race-inspired independent suspension.

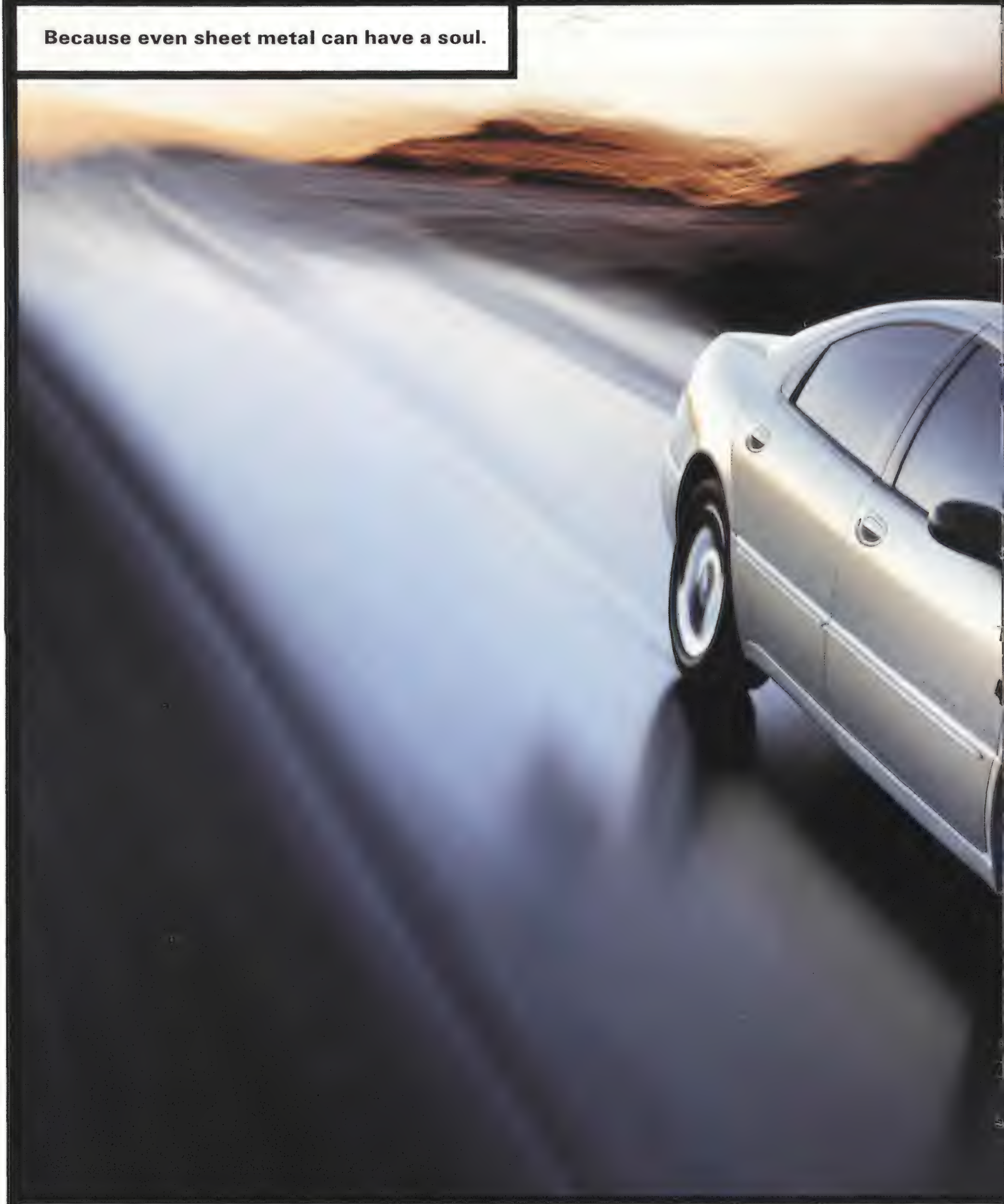
Because sophistication and fun are not mutually exclusive.



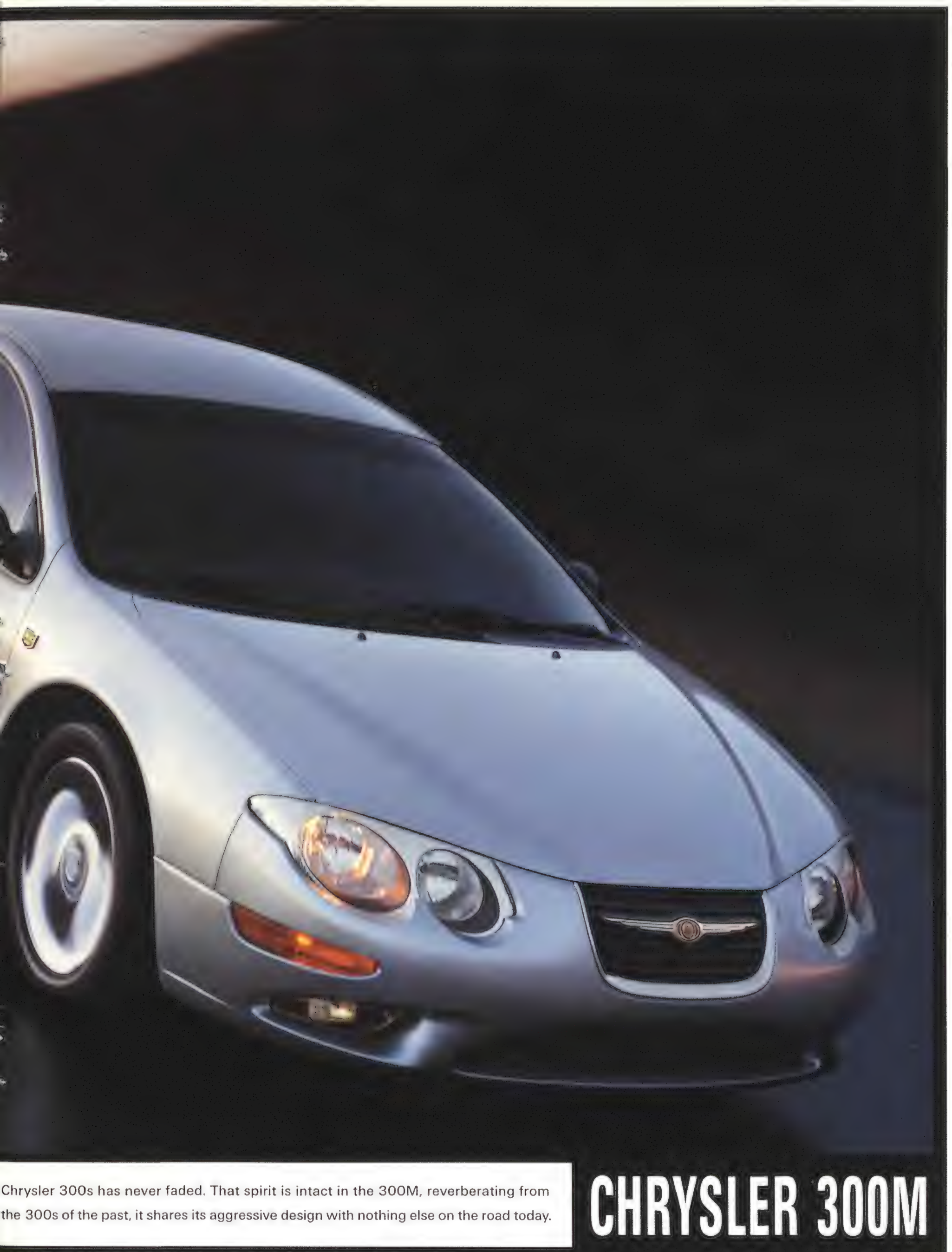
own to be driven anytime, anywhere. Whereas Sebring Coupe offers
short, two very attractive alternatives. One very difficult decision.

CHRYSLER SEBRINGS

Because even sheet metal can have a soul.



Its ancestors conquered Daytona, shattering conventions as they broke speed records. More than 40 years later, the legend of the original
an all-aluminum 253 horsepower engine that is the most powerful of any sports sedan in its class. And, while 300M shares a bloodline with



Chrysler 300s has never faded. That spirit is intact in the 300M, reverberating from the 300s of the past, it shares its aggressive design with nothing else on the road today.

CHRYSLER 300M

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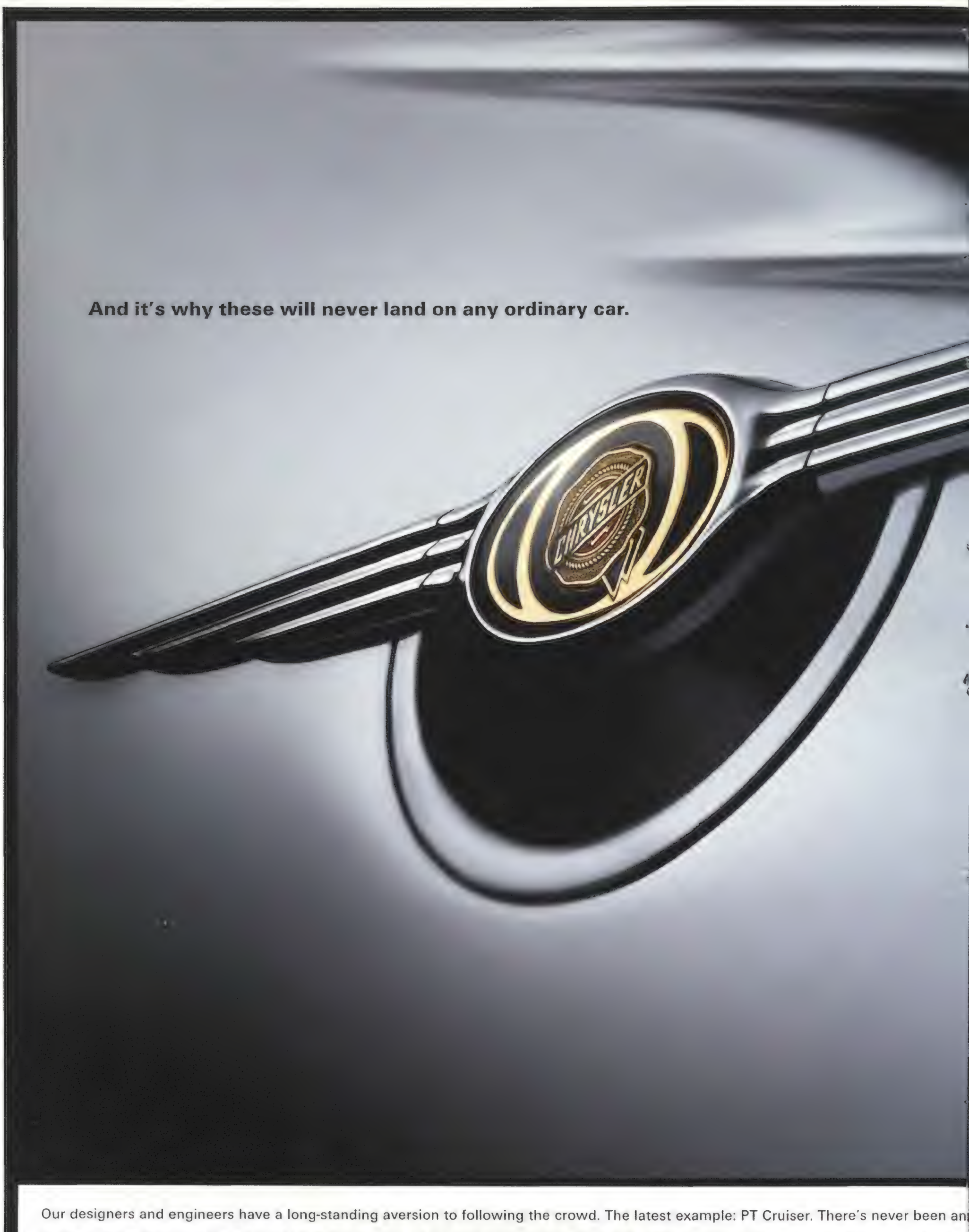
sports sedan. Breakthrough design, inventive engineering, exceptional performance: It's not any one of these things. It's all of them. Shown

hat you should be able to experience that just as strongly in a minivan as in a high-performance
rom left to right: Sebring Convertible, 300M, Concorde, Sebring Coupe, LHS, Cirrus, Town & Country.

CHRYSLER



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utomobile quite like it. Which you can tell just by looking at
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BEASTS ON HIGH

A GOTHIC MENAGERIE DRAWS EYES SKYWARD AT WASHINGTON NATIONAL CATHEDRAL

PHOTOGRAPHS BY ROBERT LLEWELLYN

Gablet terminations on a flying buttress on the northern side of the cathedral's nave include a caricature of carver Vincent Palumbo (inset) whistling at the girls of National Cathedral School who assemble for chapel every Friday. Angelic former cathedral dean Francis Sayre, Jr., looks on in outrage and surprise.

"IT WAS TOO HUMAN TO BE called like a dragon, too impish to be like a man, too animal to be like a fiend, and not enough like a bird to be called a griffin," writes Thomas Hardy in *Far From the Madding Crowd*, invoking a frightening image of a gargoyle perched high atop Weatherbury Church in Wessex, England.

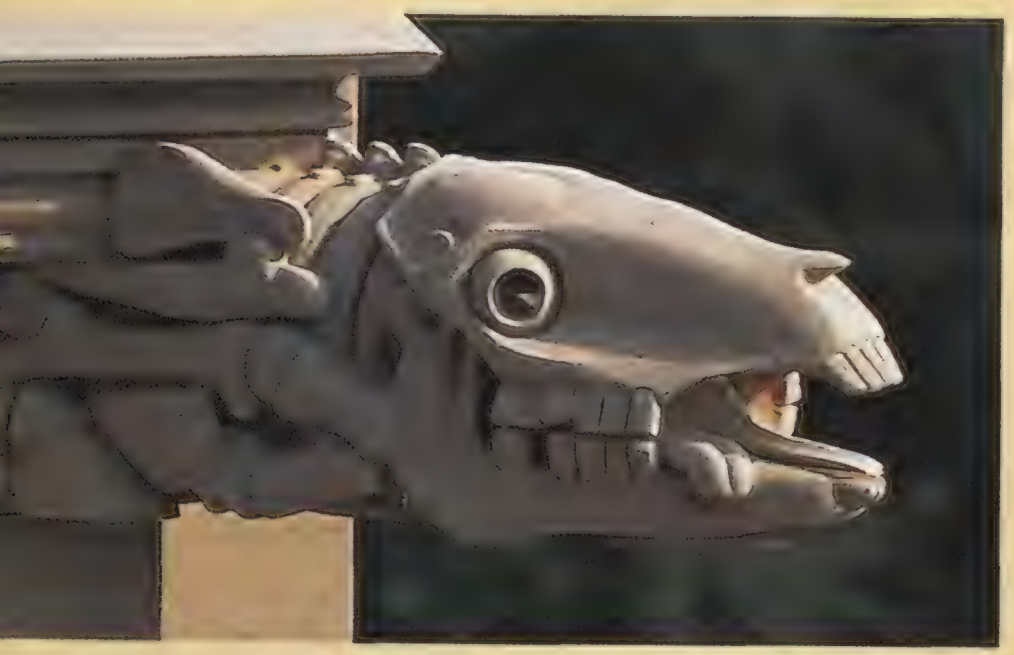
A legacy of the medieval delight in adorning cathedrals with antic stone fantasies, the spirits of gargoyles and grotesques have crossed the Atlantic and come to haunt the upper reaches of the Cathedral Church of Saint Peter and Saint Paul on Mount Saint Alban in Washington, D.C. Unlike the medieval figures, however, these creatures were fashioned by artisans during the latter part of the 20th century, so they often draw on modern imagery.

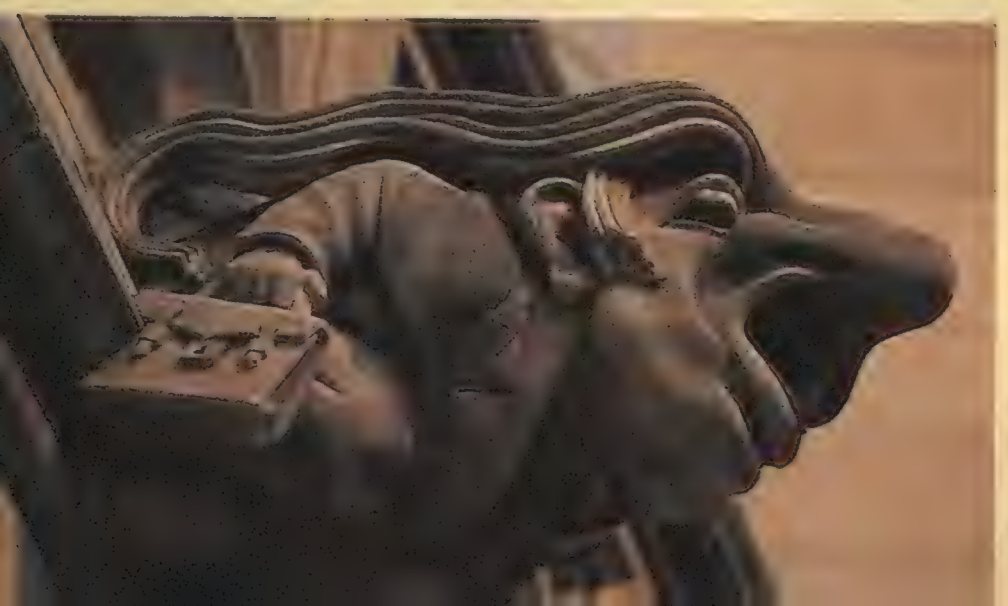
"The stone carvers' tradition of depicting themselves and their fellow workers in stone—of capturing scenes from work and life experience," writes Smithsonian folklorist Marjorie Hunt, "is a common practice going back centuries in the trade." On the north side of the nave sits the caricature of carver Roger Morigi, his legendary temper depicted by a mushroom cloud above his head. Hunt deftly recounts this and other stories in her new book, *The Stone Carvers: Master Craftsmen of Washington National Cathedral*.

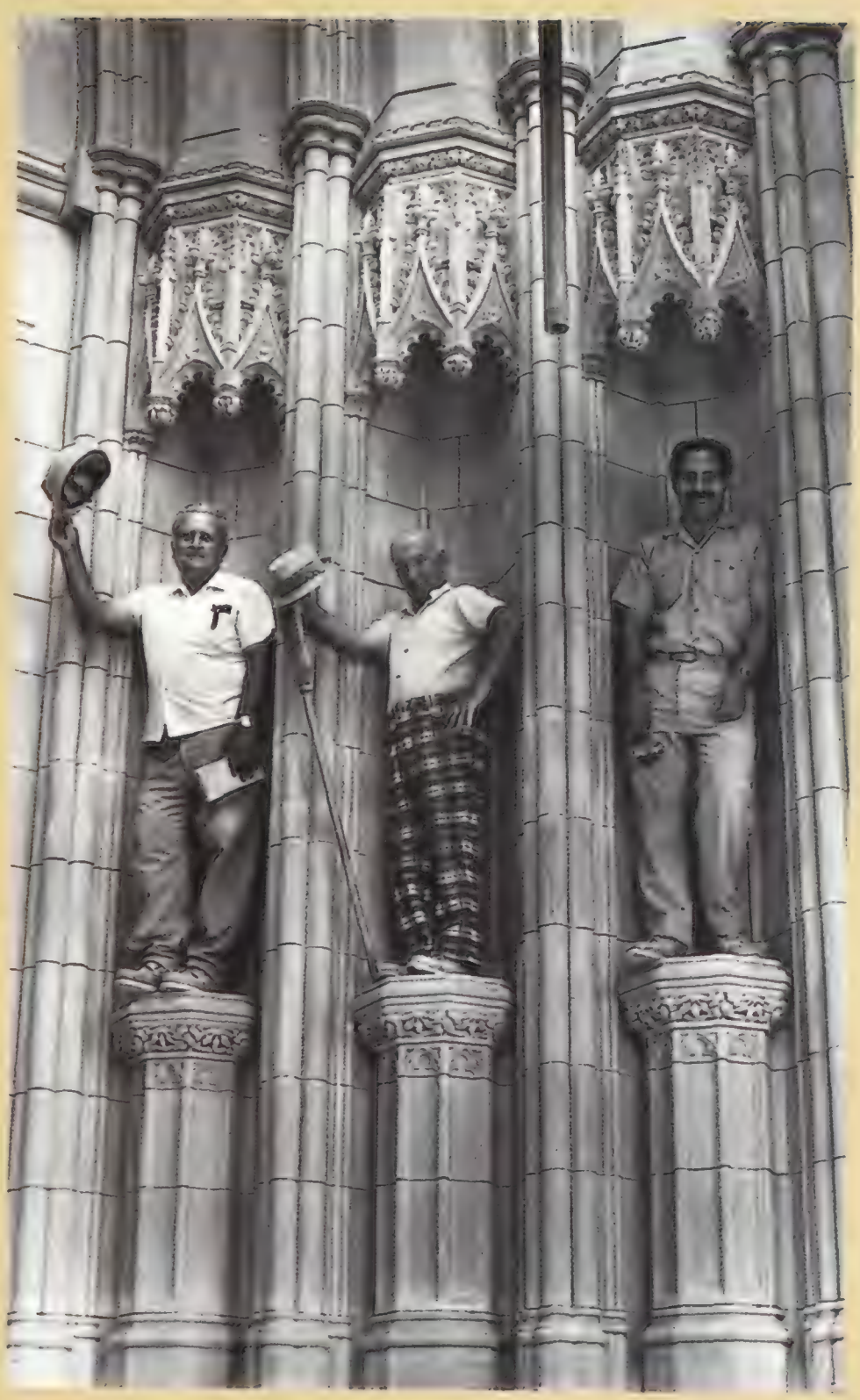
Whether designed originally to chase away evil spirits, to draw pagans to Christianity by incorporating devilish imagery into the church, or to serve a design or utilitarian function, these stone-frozen creatures amuse us, much as they must have frightened medieval peasants who cast their eyes toward the heavens to look at the cathedrals of Chartres and Notre Dame more than 500 years ago. —*John F. Ross*

DARTH VADER: HAL CONROY

Cathedral grotesquery (clockwise from top): an old man, symbolic of age and wisdom; Darth Vader from the *Star Wars* film series; a hippie gargoyle that diverts water from the cathedral roof out through the bell of a toy horn on his back; the "Pacifist," a figure clad with a gas mask.







Stone carvers (above, from left) Frank Zic, Roger Morigi and Vincent Palumbo joined dozens of other craftsmen to create the cathedral's 112 gargoyles over the past four decades. A gargoyle gallery (from top left): weeping sea turtle; boy cradling a large fish; horse skeleton; lawyer in a hurry.

PORTRAIT: MORTON BROFFMAN

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Robobiologist Tilden (inset), holding an example of the circuitry he invented, has built mechanical insectoids that adapt to complex environments. His eight inch long Unibug can sidestep obstacles easily as it traverses desert sands.

Redefining ROBOTS

AT HIS LABORATORY IN LOS ALAMOS, NEW MEXICO, RESEARCHER MARK TILDEN CREATES MACHINES THAT MARCH TO THE BEAT OF A DIFFERENT DRUMMER

BY PAUL TRACHTMAN

PHOTOGRAPHS BY PETER MENZEL

THE SIGN TAPED TO THE DOOR READS: "PLEASE DON'T Feed The Robots." Mark Tilden unlocks the door and leads me into his Los Alamos lab. He sets his laptop case on a table and walks straight to the barred windows where sunlight filters in on a large sandbox he calls his "Robot Jurassic Park." The white sand is full of tracks, and alive with several species of little solar-powered "biomechanical" insects. He watches as they sun themselves, wake up for short, random walks, and then doze off again to soak up more energy. A wire-legged bug, soldered together from tiny transistors, sensors and motors, with a solar cell stuck to its back, begins walking in one direction, then suddenly veers off in another, catching Tilden's eye. "When it makes a decision like that, what has just gone on inside its head?" he asks. "As the builder, I have to admit that even I don't know."

Tilden's workshop is like nothing else at the Los Alamos National Laboratory, perched high up on a mesa northwest of Santa Fe, New Mexico. Here, in a cluster of research warrens, scientists with their heads in clouds of mathematics, physics and space sciences can spend their days deep in thought with their digital counterparts, the supercomputers that live in what Norbert Wiener, a pioneer of cybernetics, once called "the cold, hard medium of logic." Tilden's medium is more like magic. His lab looks like an electronic boneyard of dead Walkmans, VCRs and tape decks, all of them salvaged, dissected and given new life as enigmatic machines, robots that seem to possess small minds of their own. But what kind of minds?

Tilden calls himself a "robobiologist," and watching the ingenuity, independence and true grit with which his critters get around in the world, it's easy to see why he calls them "living machines." When you pick one up and feel it scratching at your hand, or trying to crawl up your arm, you almost forget the metal. It feels more like an angry bug than a mechanical device that may someday be colonizing Mars or the Moon, or finding and blowing up land mines here on Earth.

Tilden himself is a very warm-blooded scientist, a hefty Canadian with an easy grin and a wide-brimmed hat jammed down over long sandy locks. He was born with the "engineering gene," he says, and built his first cardboard robot at age 3. He spent years working with industrial robots and artificial intelligence before inventing something very different. The first thing he wants you to know is that his robots have nothing to do with computers. "Ninety-eight percent of all species don't even have a brain to speak of," he says. "Neither do my creatures. They think the way the body thinks, and for most living things, the body is everything." When they're given a purpose, such as seeking light, he explains, they try to accomplish that purpose any way they can. To illustrate, he grabs an insectlike robot in mid-stride, yanks a

couple of its four wiry legs completely out of shape, and sets it down again. The mangled robot keeps going, dragging itself forward on its bent stumps and two good legs—looking painfully like a big grasshopper that some kid has tortured.

Tilden is pleased as punch. A digital robot, animated by computer programs rather than his transistors, would have immense trouble doing this. "Inside a computer is a perfect world," he says, "but the universe is a noisy place. We stay coherent in the noise, but computers can't think like that. They are always just a bit flip or a wire cut away from total failure." Instead, he is working with more chaotic, wavelike "analog" circuits such as gave birth to modern electronics. Tilden's ancestors are really the analog engineers like Norbert Wiener who designed self-guiding antiaircraft missiles during World War II—the first "purposeful, autonomous machines."

"Digital electronics deals with 1's and 0's, the language of logic," explains Tilden, "whereas analog electronics deals with waves, the language of sound." Tilden's robots are built from a handful of nuts-and-bolts components you could buy at an electronics store—resistors, capacitors, transistors, voltage regulators, essentially the elements of a transistor radio—and tiny motors, sensors and LEDs such as are used in a tape deck or VCR. It's the way they're wired together that makes them remarkable. "When conditions are repeated, exactly the same way twice, a digital machine will respond in exactly the same way," Tilden says. "These analog devices may or may not do the same thing twice! You can influence them, but you don't actually have any power over them."

Computers "are always just a bit flip or a wire cut away from total failure."

But the junk parts, the low-tech look and the seeming simplicity of Tilden's little machines are, in fact, deceptive. His creations may look like relics from the age of transistors (circa 1950 B.C., for Before Computers), but Tilden's magic is really a mixture of the science and engineering of the future, not the past. He is building things that can walk, crawl, slither or tumble around in complex natural environments, and solve problems and survive any number of conditions that their designer never taught them about.

For example, a solar-powered walking robot, turned loose in a field behind the lab, gets through the grass and ditches, the stones taller than itself, and the weeds snagging its antennae, without any programming from Tilden. "The machine has a natural ability to do that by itself," he says. "If it was a digital machine, I would have to program in every possible condition based upon the environment."

Typically, robots that run by computer can cost millions of dollars and take years to develop. Because they depend on rules, they get stuck when they run into exceptions. Tilden's creatures cost next to nothing, are built in days or weeks, and thrive on the unexpected. And they are proving harder to explain than build.

As Tilden keeps waving his soldering iron and turning out new species, behind the scenes a mathematician, a physicist and their supercomputer in the Los Alamos Theoretical Division are analyzing data and developing theories at the edge of our current knowledge. They are exploring uncharted seas of chaos, complexity, and other parts of the map where dragons lie, trying to figure out how these robots think. Most roboticists, with an abiding faith in the power of computers to conquer new worlds, are skeptical of Tilden's approach. In the church of artificial intelligence, he is a heretic. In the cloister of MIT, I've heard his work dismissed as "not interesting," and it's largely ignored. But the Department of Defense is keenly interested.

On a visit to DARPA, the Defense Advanced Research

Projects Agency, which funded the early development of the Internet and supercomputers, I ask about the curious indifference to Tilden's work in the robotics establishment. "I know," says Bill Warren, the young funding officer supporting the research at Los Alamos. "Most people want to dismiss this because a) it's too simple, and b) they don't understand it. That's actually discomforting in a way. I mean, that's part of the fun of this thing; gee, it's so simple, and it *does* something useful—like find land mines! It's a beautiful machine." As Warren enthusiastically shows off a couple of hand-size Tilden insects, now living in the inner sanctum at DARPA, he gives me an animated grin. "They completely dismiss it," he says again. "So that can lead you down two pathways. I mean, either they have missed the boat, or Mark has missed the boat. I guess we're going to find out!"

Another Tilden backer, John Dockery, a physicist who

Left: Tilden and a colleague, physicist Brosl Hasslacher, holding Tilden's sinuous Snakebot, set robots loose on rocky terrain. Above: Tilden's devices, including the head of red-eyed Nito shown here, first take shape on his cluttered drawing board.

became a top military analyst for the Office of the Joint Chiefs of Staff, sees the analog robots with a visionary's eye. "I regard Tilden as a pioneer who is so fundamental," he says, "that people don't relate to him. You have to judge this work by what it may develop into, versus what it's doing now." Recently retired, Dockery was a key supporter of artificial intelligence research during the Cold War, and now thinks Tilden's robots are harbingers of the future. "You have to look ahead a bit to see it," he says, "but what you've got is highly evolved digital technology smothering this in its crib. This *is* something new under the sun."

In his lab at Los Alamos, Tilden opens his black laptop case. There's no computer in it. What he pulls out is a steely black, ten-inch-long, battery-powered "ant" with its eyes recessed in protruding metal cylinders, a unicorn antenna thrust forward, and four angular legs splayed out from its circuit-board underbelly. "This is Walkman 1.5," he says, "the creature that wound up proving so much." As he grips it in his hand and powers it on, Walkman's legs start flailing in the air. It's a lot like what an insect does if you pick it up, I remark. "Watch this," he says, putting it down on the desk. Sensing terra firma, Walkman stops flailing, takes a few erratic, uncoordinated steps, then starts walking with a curious, high-stepping gait, as if awakened in a world it doesn't quite trust or understand. It picks its way over the electronic debris on the table, but stops as its antenna pokes a big metal box. Alternating flashes of red from its eye sockets throw light on the problem. Walkman assesses the light bounced back to its sensors and decides to back off. Then it crabwalks sideways for a while and starts forward again. Success!

"Here, let me show you the Scotch Tape test," Tilden says, grabbing Walkman and setting it down with a hind leg in the center hole of a thick roll of tape. As the robot senses that it's caught, we can see it trying out different ways to free itself. It tries lifting its legs higher, reaching farther forward with its front legs, pushing harder with its back legs, varying the rhythms of its gait. But how does it know what to try? "It knows," Tilden says, "because the loads, or stresses, on its legs disturb the analog wave patterns in its circuit that allow it to move, producing new and different behaviors until it finds one using the least energy."

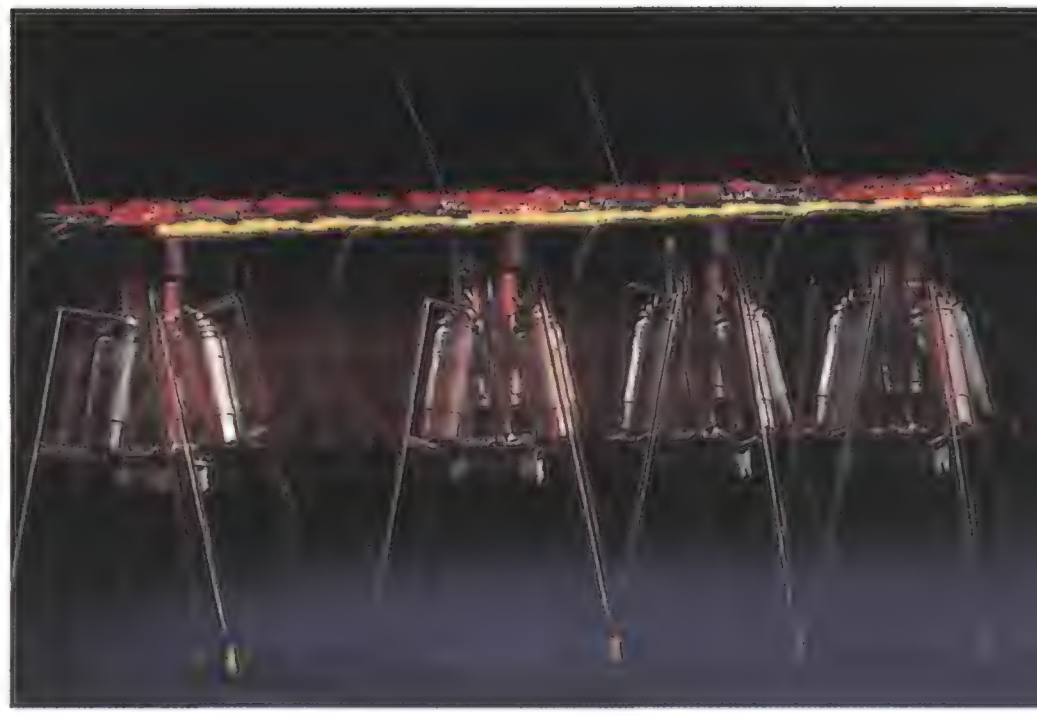
Watching all this, its creator and I share a visceral reaction to its heroic efforts to escape. "High step! High step!" Tilden urges, his whole body straining, lifting himself in empathy with the robot, as if locked in the same effort. "It's sort of 'place your bets' time, isn't it!"

Suddenly I see that the trapped leg is lifting a lot higher, and taking a longer time with each lift, while the free hind leg is making lots of quick steps, scratching at the

desktop. And then in one graceful high arc, the hind leg clears the rim of the tape without even touching. Walkman takes off without missing a step, but Tilden grabs it again and sets it back in the trap.

This time the robot lifts its leg once, twice, and on the next try it's free. "When it finds a solution and I put it right back into the situation, it gets out faster two out of three times," Tilden says. "More often than not it remembers. Not always. Sometimes it forgets." Walkman's "nervous system" doesn't seem complicated enough to have a memory, but damned if it doesn't have one anyway. It can remember because electrical waves have inertia, a certain energy that fades away only gradually. So the waves hold onto their shape even after the stimulus ceases or changes, and that's the equivalent of a very short memory.

Walkman is primitive, almost prehistoric, compared with newer species of "parallel life" around the lab. But it was the first and simplest design to prove the power of Tilden's "chaotic engineering." With five tiny motors and a nervous system of just 12 transistors, its anatomy is so simple that it seems to defy logic. When he first showed Walkman at an MIT seminar, Tilden recalls, the guru of



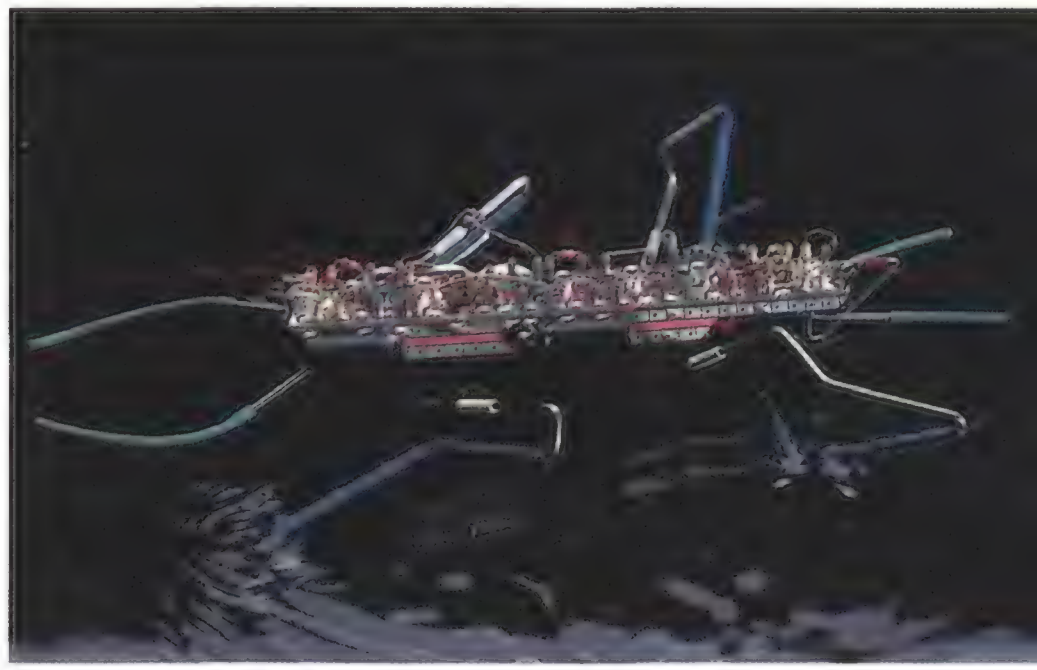
"Where's the wireless modem chip? It's got to be linked to a computer!"

artificial intelligence, Marvin Minsky, took one look at it and said, "It's impossible to walk with 12 transistors." When it started walking, Minsky walked off, too. With a laugh, Tilden says, "The others there kept poking at it and asking, 'Where's the wireless modem chip? It's got to be linked to a computer!'"

When Tilden tries to explain what makes Walkman tick, it's easy to sympathize with the MIT skeptics. It's a lot like falling through a robot hole into an Alice-in-Wonderland world of analog electronics, where everything keeps turning into something else. But falling into Tilden's analog world is an adventure worth all the confusion, for you will run into the most amazing creatures here, and they seem to reveal some hidden truths about the nature of our own world. "If I show you something that walks around and I say, look, 12 transistors, I can draw you the circuit and you can do it yourself, then there's no magic happening here," Tilden says. He corrects himself. "I'm sorry, there *is* magic, but it's not a magic you can't understand."

Tilden leads me to a blackboard, where he draws a diagram. He shows me a simple arrangement of transistors, or switches, wired together in a loop that is connected to motors and sensors. This is Walkman's neuroanatomy. Even to my untrained eye, a paradox leaps out of the diagram. The elements may be few and simple, but each one is linked to others in an overlapping pattern of interconnections. At this point, I'm not sure what "simple" means. There is a potential both for chaos and for regular periodic patterns in this circuit, Tilden points out, which allows Walkman to adapt to its environment. "The world completes the robot's architecture," he says. "Without the world, it wouldn't do anything very interesting."

Within the core of the circuit, Tilden explains, transistors oscillate, thereby producing rhythmic pulses of electricity. A robot's different walking behaviors will then result



A trio of Tilden's cutting-edge critters include (clockwise, from top) Strider, fitted with four stilt-like legs, stalking along in time-lapse sequence; Spyder, endowed with plenty of arachnoid attitude; and Unibug, wading through a sheet of water.

from different rhythms, as the oscillators fall into sync.

At the heart of Walkman's abilities is a tiny two-transistor neuron that Tilden invented and patented. His "nervous net" neuron is essentially a loop of oscillators, he explains. They emphasize the chaotic elements of electrical signals. "Think of it as a disco with four bad drummers at the corners of the dance floor," he says. "Each one's going bash, bash, bash, and ultimately they start listening to each other, because it's a small disco. And after a while they will find certain beats and form a song.

"Now the signals you're generating are not just on-off, on-off; they're bash-bash, bash-bash, and what happens is, after a while you find people discovering backbeats and harmonics and all kinds of stuff. That's the best analogy I can come up with. Imagine the different sorts of ways they

fall into different sorts of patterns. Then you get a glimpse of what it means to be a nervous net."

This applies to all of his robots, Tilden says, although some have more drummers around the disco. "Each creature has its own intrinsic songs," he explains. "And when you take these creatures and put them under stress, guess what happens to the nervous nets? They fight to hold onto their song harder. If you push them too much, they'll go into a different song."

Tilden's disco is a very nonlinear place, and so are his nervous nets. "If you use neurons in a linear way, you get nothing of facility or ability," he says. "You get million-dollar robots that can barely walk around in a box. Every animal on this planet thinks in analog. Nothing in the universe thinks in digital except for the computers we've built. And computers can't live off the desktop. We use neurons in a chaotic way; the firing of these neurons matches the complexity of the world."

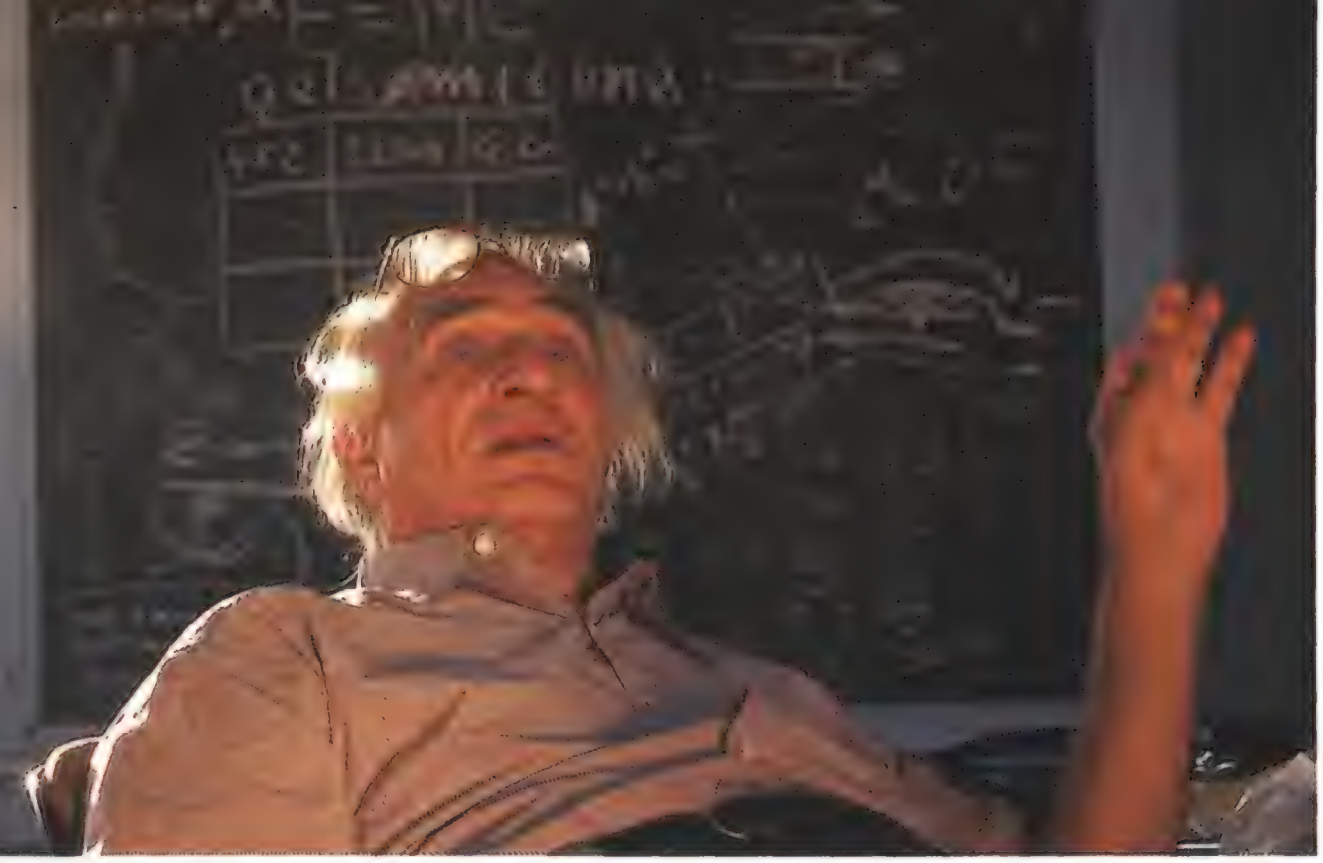
As for his robots, Tilden explains, while their neurons are nonlinear elements, their sensors and motors are strictly linear devices, and must be so, in order to keep the robots in a stable state. The sensors give a precise report of the world, measuring load on the motors, pressure, heat, light, or any other elements the robot's chaotic brain must know about to survive. "When you are a goal-seeking creature, you have to have a brain which is inherently chaotic, but quelled by linear motors and sensors that act as its regulators.

"And of course, this is the ultimate heresy," he goes on. "Because all our psychology, psychiatry, artificial intelligence, many studies of consciousness, are based on the concept that we are rational animals. No! We are a solid core of pure chaos bounded by linear systems keeping us regulated toward some level of cohesiveness with our world. We are chaotic creatures who are made rational by our environment."

At times, Tilden seems like a Don Quixote, tilting his lance at windmills of artificial intelligence. But he is also a brilliant engineer who, in the next breath, waxes as poetic as a RadioShack parts salesman, describing the "microcore," the four-neuron ring of oscillators animating Walkman. "I'm here at Los Alamos working with nonlinear theorists," he observes, "because I can build something that thinks it's chaotic, give it legs, and all of a sudden it pulls itself together. It's a brand-new way of thinking about thinking." There's that glint of heresy in his eyes now. "Some AI people don't believe it when they see it. How on earth can a machine that is chaotic at its core make a decision?" He smiles. "It just does! Get used to it! You don't have to explain it! It happens!"

Then he picks up a foot-and-a-half-long, two-headed, segmented, cylindrical, shiny steel creature with an eye at each end, and hands it to me. "Here," he says. "Look at Snakebot." I'm holding a piece of metal in my hand. It's hooked together with wires, solder and electrical tape, with motors and small brass gears at its three joints. I know it's not alive, but I can feel it squirming out of my grip. Its two ends are reaching out and—there's no other word for it—snaking through the air. I recall when I was 6 and a teacher brought a large live snake to school, which I bravely draped around my neck. So I try that now with Snakebot, and feel the cold, sinuous, twisting movement of its smooth metal segments as it makes its way over my left shoulder, extends its head out, waving slowly in front of me, twists upward to rub my cheek, pokes its head into my shirt pocket for a moment, and finally slithers down my arm, draping itself over my elbow. All it lacks is the forked tongue.

As a roboticist, Tilden's mantra is: "You have to build



At MIT, Jerome Lettvin, of the Department of Electrical Engineering and Communication Sciences, has pioneered in nervous system research that complements Tilden's work.

the body first." A competent body that can survive in complex environments. That's what nature does, he's convinced. He points back to Walkman again. "Under perfect periodic circumstances, it walks in a perfect, periodic way," he says. "But against even small complexities, you start getting little nonlinear dynamics, and that's what you see as animal-like behavior. Of course, it's limited. It can't do math. But at the same time we've managed to build some pretty interesting walkers, with the intrinsic attention and intelligence that people have been looking for since the early days of cybernetics. That attention and intelligence was always lost in the details of the computer programs."

For all his single-minded faith in analog, Tilden is sort of a two-headed creature himself, or at least he wears two hats. With his engineering hat on, he cranks out new kinds of robots faster than anyone can explain them. With his science hat on, though, he spends countless painstaking hours performing "psychosurgery" on his robots, and watching what happens as he pulls out or reconfigures different parts of their brains. Hunched over an oscilloscope and computer, he pokes into his subjects with tiny probes to record their electrical "brain waves." He's gathering data and using the computer to analyze what's going on, trying to reduce some of the mystery to equations.

Tilden has spent many a long night chewing over this data with his alter ego, the Los Alamos physicist and nonlinear theorist Brosl Hasslacher. Hasslacher is tall, thin and starry-eyed, with unruly hair and an impish grin, a man who paces wildly when he's thinking hard and who talks about Tilden's robots as if he's showing you around a new cosmos.

It's a cosmos Hasslacher held in the palm of his hand the first time he met Tilden and a few of his robots. "When Brosl first saw Walkman in 1992," Tilden recalls, "he picked it up and played with it for a while, asked me some questions I couldn't answer, and after half an hour he said, 'I know how this thing works. I know where your complexity is coming from.' It was one of his fantastic leaps of intuition."

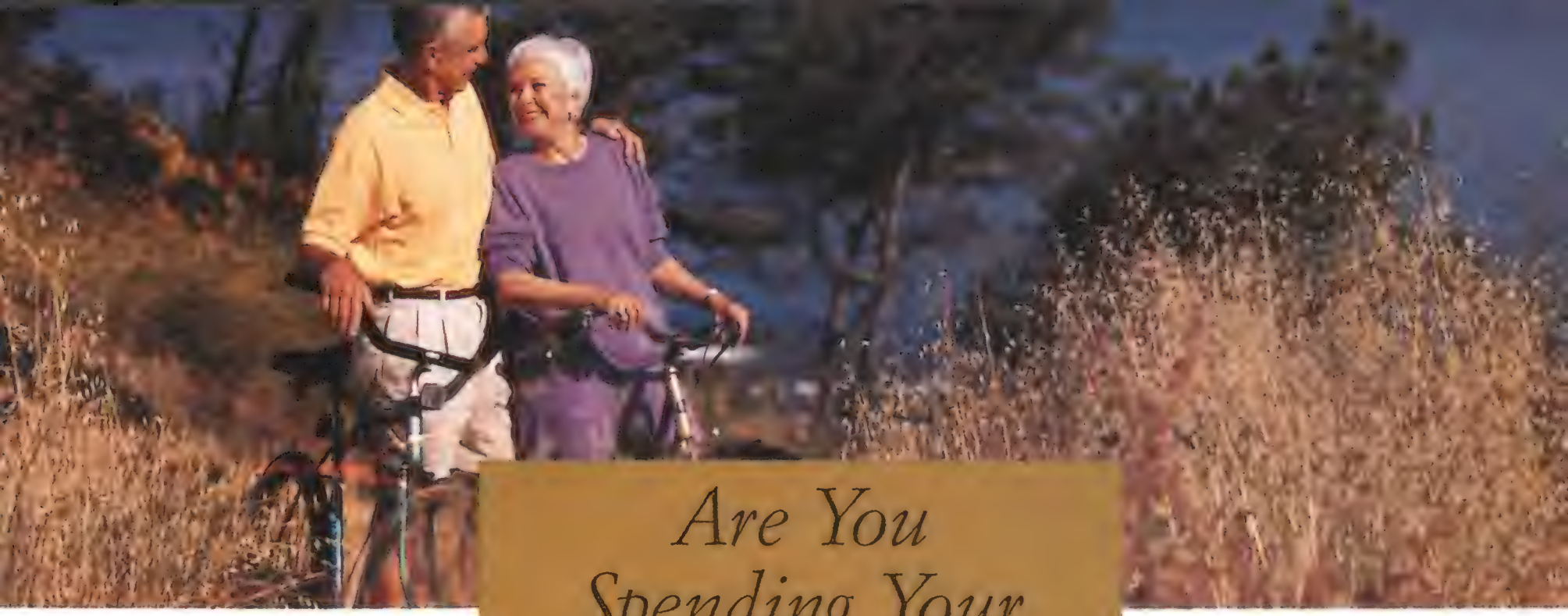
Hasslacher came to the Center for Nonlinear Studies at Los Alamos after a particle physicist's pilgrimage along the straight and narrow paths of modern science, with stops at the great shrines of theory, like Princeton's Institute for Advanced Study and CalTech. "I wrote a lot of papers in high-energy physics," he says, "and then stopped working on it. I got totally depressed because everything looked so highly nonlinear. So I came out here to study nonlinear dynamical systems because it seemed to me that one had to understand *something* about that, to get at the heart of the world."

Hasslacher met Tilden at an Artificial Life conference in Santa Fe. "There was Mark," he recalls, "with these crazy little machines, and they were not so crazy. I watched them walk through unstructured environments, and they looked like they were adapting and solving problems. It didn't look like they were doing this at random.

"I know how this thing works. I know where your complexity is coming from."

"So Mark showed me how they were built, and I concluded that he had discovered, not invented but discovered, some really basic principles. He had figured out how to use analog circuits in a nonlinear way to do very useful stuff. And they weren't programmed. All they did was survive by minimizing the energy they use, and finding more energy to keep going. And that was enough to make these machines solve problems that roboticists had not been able to solve with digital computers for the past 40 years—the problems of how to operate in an unstructured world. So I wanted to know what the 'world representation' of these things looked like, how they knew about their world. Mark and I got into this long conversation that has lasted for years.

"Essentially," Hasslacher explains, "as a machine like this walks through the world, there are different stresses on the motors, so we get different currents and voltages, and the machine knows that. So it sees the roughness of the



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At Los Alamos, Janette Frigo is adapting Tilden's circuits for robotics applications in space.

world, its brokenness, by how much current is flowing through the motors. And the different loads on the motors then change the properties of internal electrical pulses that control the creature's gait. The legs are acting as a mechanical interface between the environment and a purely electronic world—an analog world that contains most of the possible computations you could have done if you had a computer. They're all there; all the machine has to do is choose among them."

In the end, says Hasslacher, "the machine somehow generates a solution space as it's moving; it's able to choose a solution. You could call this machine an analog computer," he observes, "but I don't really like the idea of an analog circuit doing any computation. It's just a bunch of electrons flying around in a circuit, OK? I mean, it's not *computing*, it's manufacturing at the speed of light an approximate solution that a digital computer would have to solve with an algorithm.

"I mean, we don't know how they do it," Hasslacher muses, "but they do it, and they're not using sequential logic. If you tell a machine its task is survival—get more food and get better food, which in this case is electrical power—those constraints are so difficult to satisfy that once it's done it, it's almost got all the rest. Survival is such a strong constraint in the world that it may be enough to get intelligence. That's what we're guessing."

A neighbor has dropped by as we're talking. Andy Wuensche is a computer wizard at the Santa Fe Institute, working on artificial life programs based on sequential logic. He asks Hasslacher what kind of intelligence he's talking about. Hasslacher offers the image of a chicken with its head cut off. A dialogue ensues:

Andy: But when that chicken is running around with its head cut off, it's just performing some kind of repetitive motion with its legs . . .

Brosl: It's running across rough terrain.

Andy: OK, but a particular kind of behavior.

Brosl: Yes, running.

Andy: But there are other things chickens do where it does need its head. For that kind of behavior, would your machines be able to cope?

Brosl: I'll demonstrate to you that they can.

Andy: So they can peck at food, fight other chickens and that sort of thing?

Brosl: Well, yeah.

Andy: For instance, if you wanted a robot to pick things up off a table and sort them into different heaps . . .

Brosl: Oh, it doesn't like to do *that* stuff. That's *logic!* That's linear logic!

About 50 years ago, at a Manhattan hotel, a small and elite group of scientists were deeply engaged in dialogues just like this, arguing over the analog or digital nature of nervous systems, and what kind of machines could be said to think. The participants were inventing a new field of science, and their discussions, known as the Macy Foundation Conferences on Cybernetics, went on for ten years. A young Austrian physicist, Heinz von Foerster, became an editor of those dialogues, which he later compared in loftiness to Plato's *Symposium*.

In March 1952, a British psychiatrist, mathematician and fellow tinkerer, Ross Ashby, came to talk to the group about a new machine he had built. Ashby had written a pioneering book on the engineering principles for designing a brain.

The members of the Macy group were used to the idea of machines that could think, although they couldn't agree on what thinking was. The great mathematician John von Neumann was building the first digital computer at Princeton. Claude Shannon, a pioneer of information theory at Bell Labs, had shown the group a "tin mouse" that could find its way through a maze and remember the solution. An ingenious British engineer, W. Grey Walter, was building an electromechanical "tortoise." It would head straight for a light, and could bump its way around obstacles to reach it. And Norbert Wiener had constructed another light-seeking automaton, his "moth," to show how different feedback loops might mimic neurophysiological disorders such as Parkinson's disease.

As the scientists studied these analog devices, engineered with vacuum tubes, primitive photocells and mechanical

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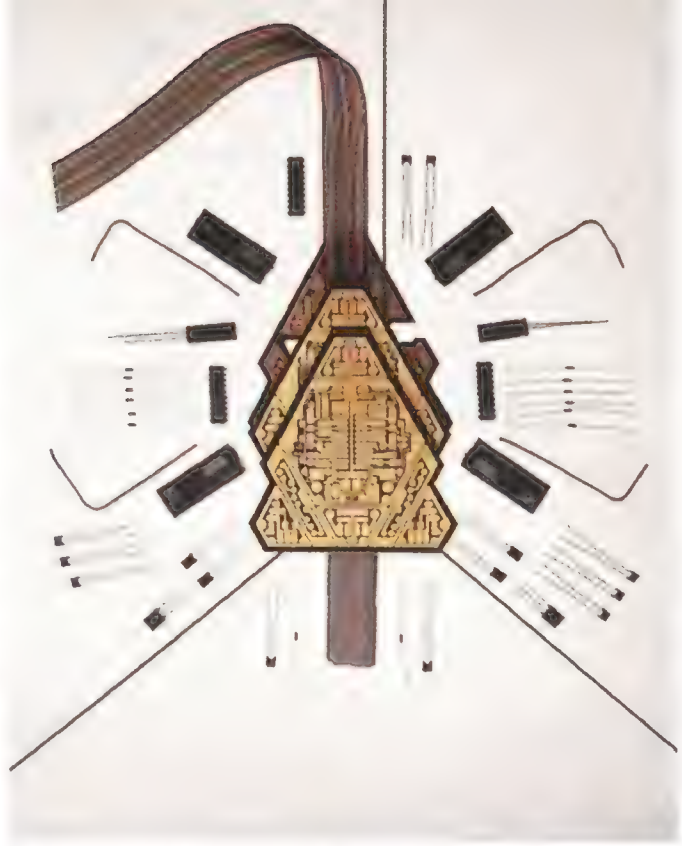

A dissection of Unibug 3.2 reveals the robot's 50 components. The device mimics many behaviors demonstrated by living insects.

relay switches, a hot debate simmered from year to year about the nature of the brain and whether it was built on random or logical principles. Neurophysiologist Warren McCulloch had theorized that the "on or off" firing of neurons was akin to the "true or false" in logic. Von Neumann's digital computer used "on or off" switches to think logically, seeming to mimic biology. "The brain is a logical machine," McCulloch argued. But physicist Donald MacKay disagreed, reminding his colleagues "of the often-ignored distinction between human *thinking* and human *logic*."

Ross Ashby showed up with a device that threw away logic, thrived on noise and behaved in ways no one could predict or analyze. He called it a "Homeostat" because he'd built it as a model of the systems regulating homeostasis, a living organism's process of maintaining critical functions—such as temperature and heartbeat—in equilibrium. And as he described the principles of the homeostat, he could have been talking about Mark Tilden's robots, years before Tilden was born.

The Homeostat, Ashby told the group, was "a mechanism which faces a hostile and difficult world and has as its fundamental task keeping itself alive." Ashby's machine was a box with four electrically activated arms. Any arm that was disturbed threw the other three out of sync. Eventually, the flailing arms would achieve a new balance. Ashby added a second order of complexity: each arm could go randomly into any one of 25 electrical states. He calculated that his machine had 390,625 possible electromechanical states. It could take hours or days to find a solution once it was disturbed, but it always found one and came back to rest.

Ashby guessed there was more order in his machine than met the eye.

The Homeostat was remarkably robust. Ashby demonstrated this for von Foerster one day by taking a hammer and knocking down some of its vacuum tubes, the equivalent of Tilden wrenching a robot's legs out of shape or tearing out parts of its circuit. The Homeostat reorganized itself and kept working. And in one of the most intriguing parallels with Tilden's robots, Ashby guessed there was more order in his machine than met the eye. He spent endless hours disturbing it and watching it return to equilibrium. "Ashby," recalls von Foerster, "was watching the essentially chaotic operation of this machine, learning what is chaos!"

In the end, though, the significance of Ashby's Homeostat was little understood by many who saw it. It was called "a machine to do nothing," and it was soon forgotten. Mathematician Julian Bigelow spoke its epitaph at the Macy meeting: "It may be a beautiful replica of something," he said, "but heaven only knows what."

On a visit to von Foerster, now in his 80s, I wind upward through mistletoe-draped oaks to the top of Rattlesnake Hill along the California coast, where he lives like a retired wizard. As director of the Biological Computer Laboratory at the University of Illinois, von Foerster had lured Ashby from England to continue his research. I ask about the Homeostat. "I think the question is, can we explain these processes?" he says. "And my proposal is, we have to learn to deal with things we can't explain. This is the way of thinking which I call magic. Magic is the art of handling situations which in principle you cannot explain. That means you live in a world which is inexplicable, and you yourself are inexplicable, and you find the art to worm your way through that incredible puzzle. That is magic."

I tell him about Tilden's robots and their resemblance to Ashby's machine. "OK, very good," he says with delight. "I'm glad it's not dead. It's climbing out of its grave."

Another cybernetic wizard, Jerome Lettvin, a retired MIT professor of both physiology and engineering who's still active in research, shares von Foerster's delight as I tell him about Tilden's robots. Lettvin meets me at the top floor of Building 24 on the monolithic MIT campus. As I step out of the elevator he beckons me to follow, and ducks through a door leading off the corridor and up a flight of metal steps to a second door, this one locked. "They insisted on giving me a key," he says, "although I told them I could pick the lock just as easily." The door opens out onto the roof, where Lettvin ushers me into his aerie, a ramshackle old shed once used for launching weather balloons, now furnished with his desk, a few chairs, a blackboard and little else. "It's the only place I could find where they won't arrest me for smoking," he says.

As he settles his large frame behind the desk, the cold

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wind rattles the old shed and whistles through the cracks in the wall. "It's a lot of fun to build robots," he says. "There are a number of ways you can build things. You can build them on a discrete model, a logical model like artificial intelligence, which is sort of a death knell. We are not digital machines, we are analog devices. All our neurons are analog devices, and anyone who tells you otherwise is talking nonsense."

This solar-powered walker, equipped with circuit boards for its oversize feet, is designed to analyze and collect soil samples.

I start to describe what Tilden is doing. Lettvin listens patiently. "Sure, it's a very, very intelligent approach," he says. A life of pioneering research on the nervous system has convinced Lettvin that you can't explain mental processes by analyzing neural mechanisms. "It's nice to talk neurons," he says. "But to understand how they operate in a system is a very different story, because you have to know the whole system to be able to do that, and you can't know it. What you have is a state of a single neuron which is contingent on the state of all other neurons. But everybody's so committed to computers, all this digital-logical-neuronal stuff, that they think we can understand it if we work at it long enough. My answer to them is: 'I'll make you a bet.'"

I ask Lettvin what he thinks about Tilden's use of words like "biomorphic" or "living machines" for his robots, and the temptation to talk about their "deciding things" or "making choices," as if they were alive. "Why not!" he laughs. "The analogies are very abstract. It's a way of talking about things that you can't explain."

When I see Tilden again, it's at his home in Los Alamos, a bachelor's condo he shares with some of his most enigmatic creatures. He introduces me to Strider, an erect "eosapien" who walks toward me with amazing grace. Strider is only a foot tall, with four long wire legs carrying its cylindrical body high off the ground, a stiff copper neck and a wide, flat head shaped from interlaced hexagons bejeweled with analog chips and blinking LED lights. Strider pauses, swivels its head from side to side for a while, and then decides to approach me.

Each leg moves independently, but in sync, in that balancing act Norbert Wiener once called "a continual jujitsu against gravity." Sensors on its motors and its feet help it stay upright. Red lights blink as Strider walks, or stops to inspect the world. A frontal yellow light provides illumination for its wide-set blue eyes, recessed and shadowed under the flat circuit board that serves as its head. The eyes sense both light and infrared, or heat energy so Strider can find a human even in the dark. As it gets closer, it walks off to one side while keeping its eyes on me. Then it stops, swivels its head more widely to scan the surroundings, sees something more interesting and backs away. I've been rejected!

Eosapiens like Strider became possible when Tilden discovered what he calls his "unicore" structure. "It's the smallest structure of neurons that gives the greatest range of stable behaviors," he says. "It gives the robot a 'neural net' brain that holds onto patterns of stimuli from the environment. These patterns serve as a form of memory. This brain isn't a digital computer; it's another analog layer that holds onto electrical charges representing patterns of behavior. So a creature 'remembers' what it has done, enhancing its competence.

"And this brain is connected to a 'nervous net' body that can hold onto rhythms. Walkman is a creature that dances around rhythms very effectively. It does a pretty good job of surviving. But it's limited, it can't evolve much further. With the unicore, you can actually remember, and move, and then close that loop, so you have a structure which is pretty close to being an artificial life-form. The first creature that used it was Strider."

The secret of the unicore is the neck. "It took years to find that," Tilden says. "I built heads and heads and heads. I tried everything—two brains slapped together, two bodies slapped together, a brain and a body slapped together. Only a few survived for any time. It's not enough to be a brain and a body. It's a brain *connected* to a body. The body has its own competence. The brain has its own awareness. The connection determines how one is mapped onto the other, bidirectionally.

"Imagine you're walking with your wife in one hand and your young son in the other," Tilden explains. "He says slow down, she says speed up. She wants to go to the store, but he's tired of walking all day. What do you do? You act as a mediator who effects a compromise between the two. You're telling your wife to slow down, but the information is also being transmitted to your son.

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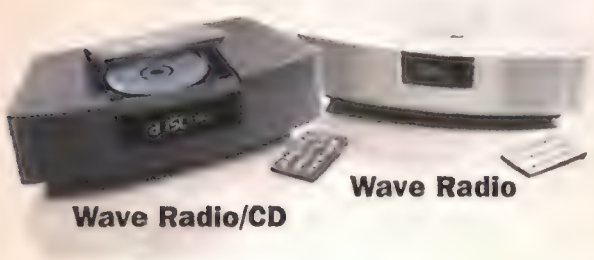

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Out for an afternoon stroll, six-foot-high Roswell, christened for its space-invader appearance, peers over a fence. The state-of-the-art robot is equipped with 16 different classes of sensors in order to process and traverse its environment.

He thinks "Oh, Daddy is trying to help me!" This sort of thing is what happens in these analog systems. Everybody knows what everybody's doing."

There is a small black button on Strider's head. Pushing it kills the connection net, leaving the robot's brain and body directly connected, devoid of an electronic mediator. Tilden pushes the button. Strider has been walking around his desktop, a landscape lit by small halogen lights and a laptop screen. The robot stops, turns its head in erratic arcs and backs up with a few jerky steps. "It'll back away from any stimulus that upsets it," Tilden says, "like a yuppie in a biker bar. I've turned this poor little robot into a perfect paranoid."

He settles down to watch Strider's behaviors. "I love it," he says. "There's something about building a thing that has more behaviors than you're comfortable with. It's like the old magician's trick where you wave your hand and something comes to life and goes off to become your demon. This is about as close to a real magician's trick as I can manage."

Eosapiens such as Strider, just beginning to evolve in his hands, embody the age-old quest to put mind into a machine. "Strider is a prototype for Roswell," Tilden says. "When I built Strider, I realized I had the power to build something six feet tall that would have an incredible structure to it. Not just the two or three sensors this creature has right now, but something with dozens of sensors, and abilities, and a real depth of complexity." Roswell's head, torso and legs are dismantled in Tilden's lab right now, awaiting further engineering after a brief, peripatetic existence. "When it was up and working," he says, "it would walk down the hall and terrorize the secretaries." One of them, Lucy Maestas, met Roswell without its complete head. "I walked into Mark's lab one day and I said, Oh, my god!" she recalls. "I'm all of five feet, and this thing was about as tall as me, with long spindly legs, like a tarantula. He switched this little button on, and it stood there and kind of looked at me, and when I started to walk away it sort of walked with me! It's creepy! It seemed so alive."

Bill Warren, Tilden's sponsor at DARPA, is among those who met a headless Roswell. "It's kind of eerie," he says, "because it's not directed motion. So you have this thing that's a little bit chaotic coming toward you. Half of you wants to sort of take it on, you know, as if you want to test it a little. And the other half says, well . . . " After a pause, he finishes the sentence, ". . . I wouldn't want to break it."

In Tilden's living room, as he talks about building larger-than-life robots who will outlive him, Tilden starts to sound less like Don Quixote and more like Mary Shelley's mad scientist. And he relishes the role. "Roboticists are all self-contained, arrogant megalomaniacs," he laughs. "And thank God. It's very necessary that we are so. You have to have this sort of Frankensteinian complex to be a Frankenstein creator."

Tilden's robots have survived sandstorms to locate unexploded land mines.

But parallel life is no fiction. Tilden's analog genesis will spawn robots that may soon find military applications. They've already been tested at the Yuma Proving Ground in Arizona, where they successfully survived searing heat and sandstorms to locate unexploded land mines. They will soon be at home in space. One of Tilden's Los Alamos colleagues, Janette Frigo, has adapted his circuits to serve as a backup robotic control system on an experimental Swedish satellite. Frigo, a young rocket scientist who considers herself a linear thinker, is the real Alice in Tilden's Wonderland, enjoying the magic but working

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with digital computer simulations to test and adapt that robotic system in space. "I'll be working right up to the launch, no matter when they set it," she says. "I'm doing computer modeling of all the contingencies, and you have to be really paranoid about it because you're going to depend on it in space." At DARPA, Bill Warren sees Frigo's work as a giant step for the robots. "Getting something into space is *extremely* hard," he says. "And they've broken that barrier. If their system works really well, you're going to see a lot of people interested in it."

Faced with the problem of negotiating a stone-strewn course, an undaunted Unibug demonstrates its ability to devise solutions and press on with its task.

Back on Earth, in Tilden's living room, such realities are lost in the drama at hand. We stare at an experimental head for Nito, an advanced eosapien that is slowly emerging from Tilden's mind. I am witnessing robot evolution. This is a three-inch-wide head for the first robot with what Tilden and Hasslacher call an "ego." It's a hexagonal structure, gold and black, shaped like a rattlesnake head with electronics, six eyes around the periphery and two tiny searchlights in front so it can see in the dark. Neck motors move the head up, down and sideways so smoothly that it could track a fly in the air.

"Nito takes the unicore structure to its next logical level," Tilden says. "A unicore like Strider has three layers—a brain, neck and body. Its mind is a representation of the world. When Brosl saw the first unicore, he asked me, 'What happens if you expand these things?' One way to do that, Brosl proposed, was to stack one unicore into another, so the first one is walking in the world, but the second one is 'walking' in the other's mind, in its world representation. So now you have a brain on top of a brain that is not connected to the real world. At that point, you should have something that is aware of itself. That's why we call it an 'I' machine."

Nito is the head for this machine, the "intellectual rider" atop an eosapien that Tilden hasn't built yet. Nito is Tilden's answer to Cog, the famous artificial intelligence robot built by Rod Brooks at MIT. Nito embodies Tilden's belief that building intelligent machines must begin with an ability to survive in the real world, not with abstract algorithms and logic. Eventually, more abstract brains could be added on, although he thinks even those will be analog. Tilden often uses the image of a horse and rider, comparing the intelligence of his robots to that of the horse, which knows how to get there when the rider gives it a goal. "I'm just trying to build John Wayne's horse," he says. "John Wayne is a job for other people. They have a much more contentious job than mine, arguing about what is truth, what is beauty, what is mind. I don't care. What I'm after is the framework upon which you might be able to recognize a living structure. That's what I see Nito to be."

The defense analyst John Dockery sees Nito as a creature both of history and the future. "When the cybernetics field started off, there were passageways you could go along," he says, "and the field took off down one with great success. That was artificial intelligence. When that happens, other passages get stubbed off. What Tilden has done is go back all the way to the beginning and explore another passageway. So people's reaction is, 'It's been done before,' or 'It doesn't fit in the stream we're used to,' and they don't know what to do with it.

"But Tilden isn't waiting for them. I'm reminded of Indiana Jones. He just tackles problems and what he does works, and that's the criteria for him, and it's kind of an adventure. Now he's taken one robot and put it inside another, so that the output of one becomes the input to another. Suddenly you've got a thing which is both in touch with the environment and buffered from the environment. And I don't know what that is. It's some kind of abstraction. You have the beginnings of a purposeful machine the like of which has not been anticipated. I don't yet know what that is."

"You have a machine that is aware of itself—an 'I' machine."

Contributing editor Paul Trachtman, a former science editor at Smithsonian, *is a freelance writer based in New Mexico. Peter Menzel is working on a new photographic book,* Robo sapiens, *for MIT Press.*

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BY STANLEY MEISLER

Splendors of Topkapi

PALACE OF THE OTTOMAN SULTANS

FOR CENTURIES, THE WESTERN world was fascinated by the marvels and mysteries of the Ottoman Empire and the sultans who ruled their vast domains from the Topkapi Palace in Istanbul. Writers, composers and artists celebrated or satirized the omnipotence and opulence of the sultans and the secrecy lurking in the harem. The creative works about the Turks were so numerous that the French had a word for the genre: *Turqueries*.

The examples are plentiful and well-known. In the 17th century, Molière's *Le Bourgeois Gentilhomme* ridicules a bourgeois father who allows a young man to marry his daughter only after the suitor pretends to be the son of the sultan. In the 18th century, Mozart's opera *The Abduction from the Seraglio* tells the story of two kidnapped young women who are freed from a pasha's palace. In the 19th century, Ingres beguiles his patrons by painting fanciful scenes of voluptuous women lying languidly in the harem and Turkish baths.

All this came to an end as the Ottoman Empire dwindled over the years and then crashed apart in World War I, soon bringing the dynasty of sultans down with it. Although tourists come to Istanbul every year, a fascination with the Ottoman sultans no longer grips the Western imagination.

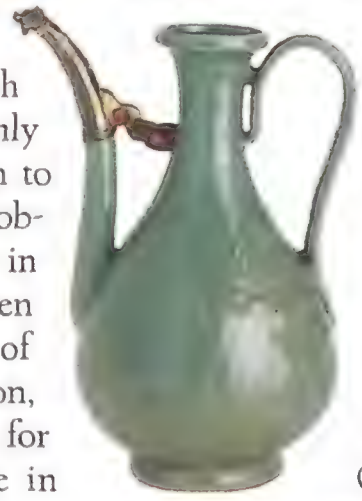
Floral motifs adorn the gold-plated horse's head frontal (left), made specially for the sultan's horses. The notorious Topkapi dagger (above) is laden with precious stones.

Now the rest of the world receives only occasional reminders of the sultans and their empire and palace. Images of grandeur and power from old history books come back to us, for example, when war breaks out in former provinces of the empire like Bosnia and Kosovo, or an earthquake threatens the treasures in the Topkapi Palace Museum, or the government of Turkey allows a sumptuous selection of those treasures to tour outside the country.

One such reminder is on its way to the United States. A new exhibition, "Palace of Gold & Light: Treasures from the Topkapi, Istanbul," will open at the Corcoran Gallery of Art in Washington, D.C. on March 1 and remain until June 15 before moving on to the San Diego Museum of Art (July 14-September 24) and the Museum of Art, Fort Lauderdale (October 15-February 28, 2001).

The show will include the emerald-studded dagger that earned notoriety 36 years ago as the target of a band of thieves in the movie *Topkapi*, the throne used by Sultan Suleyman the Magnificent on his battle campaigns during the 16th century, and more than 200 other items, including swords and daggers, royal clothes, carpets, textiles, ceramics, manuscripts, jewels, armor, paintings and finely crafted objects of art. Organized by the nonprofit Palace Arts Foundation and largely curated by Tulay Artan, a social historian at Istanbul's Sabanci University, the exhibition will endeavor to relate these treasures to the history of the Ottoman Empire and the Topkapi Palace.

The show comes to the United States at a time of soul-searching in Istanbul over the Topkapi Palace. The August 1999 earthquake, which killed thousands in western Turkey, caused only minor damage to the palace, but called attention to Topkapi's inadequacies as a museum. A daring robbery a few weeks later undermined confidence in the complex's security. In addition, visitors often leave Topkapi with a confused understanding of the palace and its history. Some of the confusion, scholars say, comes from the nature of the place, for it is a hybrid—part museum like the Louvre in France, part historic building like Versailles.



"The Topkapi has to decide," says Filiz Ozer of Istanbul Technical University as she rushes through the rooms of the harem, "what it is going to be—a Versailles or a Louvre. I am an architectural historian, and I have spent much of my life in this palace. At every corner, I see something wrong, and it breaks my heart." But even experts who agree with her cannot agree on what should be done.

The Topkapi complex (top right) looks out across the junction of the Bosporus and the Sea of Marmara to Asia. Its collections boast such treasures as a 15th-century Ming celadon pitcher (above).

From afar, the Topkapi Palace is a sterling sight—a walled array of domes and turrets and minaret-like chimneys and belvederes commanding the city from on high.

The Topkapi Palace was built by Sultan Mehmed II, "the Conqueror," after his army stormed and sacked Constantinople in 1453. The fall of Constantinople, the last outpost of Christendom in the East, shocked and frightened the rest of Europe. Mehmed understood the symbolic importance of conquering the city that had once served as capital of the Roman Empire. He took "Roman Caesar" as one of his titles, declared Constantinople (which soon became known by the Turkish name Istanbul) capital of his Ottoman empire, and built a new palace from which to rule his vast domains. Claiming Alexander the Great as his model, Mehmed ordered courtiers to read portions of a Greek biography of the Macedonian conqueror to him every day. The book is still in the Topkapi library.

As the site of the new palace, he chose the ancient Byzantine acropolis, high above the confluence of three

P. 114 SELAMET TASKIN/TOPKAPI PALACE MUSEUM; PP. 115-116 HADIYE CANGÖKÇE (2)

YANN ARTHUS BERTRAND/CORBIS

vital bodies of water: the Bosporus, which separates Europe from Asia; the Golden Horn, which separates the ancient quarters of the city from the rest; and the Sea of Marmara. The palace was called the New Imperial Palace then but took on the name Topkapi Sarayi (Palace of the Cannon Gate) several centuries later.

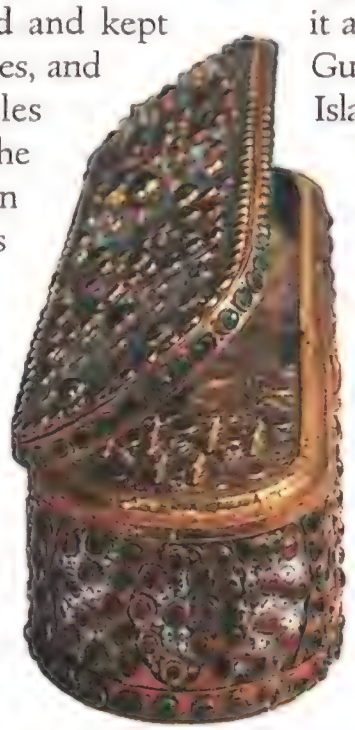
At the zenith of its power in the 16th century, the Ottoman dynasty of the Topkapi Palace ruled an empire that included Greece and the Balkans, much of the Caucasus and the Crimea, most of the Middle East, and the populated areas of North Africa. The cities of Athens, Budapest, Belgrade, Sarajevo, Bucharest, Sofia, Beirut, Damascus, Baghdad, Jerusalem, Mecca, Cairo, Alexandria and Tunis all at one point belonged to the Ottoman Empire. The sultans lived in the Topkapi until the middle of the 19th century, when their taste turned more Western and led them to a residence more like that of European royalty.

From afar, the Topkapi Palace is still a sterling sight—a walled array of domes and turrets and minaret-like chimneys and belvederes commanding the city from on high. Once on the acropolis, visitors enter the palace by passing through a monumental gate guarded by twin towers. Save for the Arabic inscriptions and calligraphic signatures of sultans, known as *tughras*, on its facade, the gate looks like the entry to a medieval European castle. But the gate does not lead to a grand building of any kind. The palace is really a complex encompassing 173 acres of gardens, courtyards and vistas, workshops, kitchens and armories, baths and fountains, offices and halls and residential areas. In its heyday, the Topkapi resembled a small city, inhabited by the sultan, his royal family and thousands of bureaucrats, soldiers, craftsmen and servants.

Some buildings now house exhibits. The most spectacular pieces in the upcoming show, the majority crafted by

palace artisans, come from a building now known as the Treasury. Other exhibits on the grounds display lavish gifts to the sultans, such as the Meissen and Limoges porcelain presented by European royalty. Some buildings—the library and kitchens, for instance—attempt to impart an idea of their original function. Some walls have original tiles and decorations and fountains; other walls are bare. The living quarters of the sultans and the harem are less like a huge mansion than a confusing, many-domed warren of interlocking rooms and courtyards.

There are stunning sights in the Topkapi. The rooms of the Privy Chamber, where sultans lived and kept their throne, still retain the gleaming domes, and the flowered and brilliantly colored tiles from the town of Iznik that decorated the complex in the 16th century. A visitor can still feel the beauty, even though the rooms are now kept in dim light because of the swords, hairs, holy mantle and other relics of Muhammad displayed there.



A visitor can also take in all the opulence of the bedroom that Sultan Murad III built for himself within the harem during the late 16th century. Murad, who did not care much for affairs of state, was regarded by Europeans as a great libertine. His bedroom, really a cluster of rooms, was designed by Sinan, the architect of some of the great mosques in Istanbul. An inscription of that era describes the bedroom pavilion as fulfilling the sultan's request for something "beautiful, exhilarating and unequaled." The walls of the enormous chamber are covered with Iznik tiles. There is a plume-shaped bronze fireplace, a gilt dome and an intricate marble fountain. "In an Ottoman room," says Filiz Ozer, "if you see running water, you know the room was a meeting place. Water conceals voices."

Two pavilions built in the 17th century—known as the Baghdad Kiosk and the Revan Kiosk—retain most of their original decoration. These lovely pavilions, replete with alcoves and windows, stand in the sultan's private court near gardens, a fountain, a pool and a gazebo. In the old days, carpets, textiles and sofas would fill the alcoves, and the sultans, accompanied by women or courtiers, would relax by listening to music, writing poetry, taking food or opening the mother-of-pearl shutters to watch the ships on the waters below. "I will tell you that these kiosks are the most agreeable buildings that the Turks have," wrote Albert Bobovi, an enslaved Polish musician who worked in the palace for 19 years during the 17th century. Visitors can still catch the mood.

Yet, despite these flashes of beauty, a visitor is likely to feel a little disconcerted leaving the palace, as if the key to it all were somehow missing. Gulru Necipoglu, professor of Islamic art and architecture at Harvard University and one of the world's leading scholars on the Topkapi, grew up in Istanbul and remembers the bewilderment of tourists unable to fathom the compound's architecture. "I once heard someone walk out of the palace gate and say to his friend, 'Where was the palace?'" she recalls.

The Topkapi manifested power through the inaccessibility and mystery of the sultan and his court. His living quarters, harem and private gardens were off-limits to outsiders.

It was Necipoglu who uncovered the key to understanding the complex. "I used to go there and look at the buildings," she says, "and I could never figure out what it was all about. Books on the Topkapi and the Ottoman Empire used to say that the palace was built in a haphazard way with one sultan adding buildings to what had come before. I began to doubt this."

In 1991, after extensive research, Necipoglu published a book, *Architecture, Ceremonial, and Power: The Topkapi Palace in the Fifteenth and Sixteenth Centuries*, that changed scholarly ideas about the origin and meaning of the Topkapi. Necipoglu revealed that sultans had renovated the palace but had never changed its original structure. That structure, in fact, resembled the layout of a traditional tent encampment when sultans led armies into battle, and embodied the imperial might of the Ottoman Empire.

Unlike a palace such as Versailles, which exuded power through its monumental size, the Topkapi demonstrated power through the inaccessibility and mystery of the sul-

Insets, from top: A bejeweled 17th-century turban ornament denoted royal power; a 16th-century jewel-encrusted pen box was likely used by a sultan. Opposite, clockwise from top left: Exterior entrance to the Council Hall; elaborate interior of the Apartment of the Crown Prince; refurbished golden dome of the Privy Chamber's throne room, now the Chamber of the Holy Mantle; 18th-century chamber of Ahmed III, also known as the Fruit Room.

HADIYE CANGÖKÇE (2); P. 119 WOLFGANG KAEHLER; ARA GÜLER; ALI KONYALI (2)

tan and his court. An outsider would typically move through the first two courts of the palace, transact business in various offices, perhaps catch a glimpse of the sultan in some ceremony, but never enter the inner sanctum. Visitors could measure their importance by noting how close the strict ceremonial etiquette of the palace allowed them to the sultan. But the living quarters of the sultan, his harem, his private gardens, his pavilions, were all off-limits to outsiders, no matter how distinguished or mighty.

"Some modern architectural critics have argued that the small buildings of the Topkapi showed that the sultans were modest men who showered their love on the great monumental mosques," says Necipoglu. "But that's not true. What seems to us haphazard and modest is, in actuality, what they considered to be a symbol of power."

Necipoglu suggests that new guidebooks and additional placards could offer visitors a better understanding of the palace. But the outspoken Filiz Ozer believes this would still leave the original function of many rooms obscured because they are now used to display museum pieces. She points, for instance, to the Treasury. "This was the original home of the sultan," she says. "It has to be changed to show that the building is more important than the jewels." Then she shrugs and adds with a smile, "But maybe this is going too far." Her afterthought reflects the ambivalence of Topkapi scholars. Some would like to transfer the priceless works of art and craft to a modern museum. Yet many fear that removing the exhibits, though sensible from a scientific viewpoint, would denude the palace of the signs of past opulence.

Yet there is also agreement that the Topkapi does not really function well as a museum. "There is no conservation," says Walter B. Denny, professor of art history at the University of Massachusetts and a well-known scholar of Ottoman art. "There is not a single climate-controlled room, not a single square inch of climate-controlled storage. It's a security nightmare. If I thought a lot about this, I wouldn't sleep at night. I worry about the things I love."

Since many of the palace's walls are ten feet thick, the complex escaped structural damage in the devastating August 1999 earthquake. But Filiz Cagman, a distinguished scholar who is the director of the Topkapi Palace Museum, says that tiles and plaster were damaged. The experience persuaded Cagman to transfer much of the palace's grand collection of china into new mounts.

The palace staff received a second blow a few weeks after the earthquake. A thief or a gang of thieves broke

ROBERT FRERCK/ODYSSEY

The Baghdad Kiosk (above) was built in 1635-38 by Murad IV to commemorate his victory over the city of Baghdad. The gold incense burner at far right bears the name of a sultan's daughter.

into the library at night and stole a section of a 12th-century Koran from a locked case. "The robbery was very scary for the museum," says Tulay Artan. "There is a fear that the thieves wanted to issue a challenge, that they wanted to say they can take anything they want." While stealing the Koran, the thieves left behind far more valuable manuscripts, leading to speculation that the crime may have been an attempt to embarrass the director. The culprits, according to that speculation, may be Islamic extremists who want the palace turned into a religious shrine.

The traveling exhibition in the United States does not try to create the illusion of the Topkapi Palace. But Artan, the curator, has bunched related pieces together to help visitors understand the significance of the palace and the Ottoman Empire. She wants them, first of all, to feel the power of Mehmed the Conqueror. The exhibition displays the sword he carried into battle, with its silver cap, bone handle and slightly curved, 40-inch steel blade inscribed in gold calligraphy. A Greek manuscript describing Mehmed's conquest of Constantinople also graces the exhibition, along with his worn blue kaftan and talismanic shirt bearing Koranic scriptures to ward off evil spirits.

"I will tell you that these kiosks are the most agreeable buildings that the Turks have," wrote an enslaved Polish musician who worked in the palace during the 17th century. These pavilions, replete with alcoves and windows, stand in the sultan's private court.

Portraits of Mehmed, including one by Gentile Bellini now in the National Gallery in London, reveal a thoughtful man with piercing dark eyes and a long, slender nose. Bellini showed up in Istanbul after Mehmed asked the doge of Venice to send him a "good painter." Mehmed spoke Turkish, Greek, Arabic, Latin, Persian and Hebrew fluently and displayed a considerable interest in Christianity, which led some European Christians to hope that he might convert. Pope Pius II promised him fame even greater than that of Alexander, Caesar or Constantine if he converted and united his empire under the Christian faith. "There is a controversy today, in fact," says Artan, "between those who believe Mehmed considered converting to Christianity and those who believe he did not."

The best-known sultan is probably Suleyman the Magnificent, who expanded the empire in bounds and came close to capturing Vienna in the 16th century. History shows contrary sides of Suleyman. A Venetian envoy described him as "by nature melancholy, much addicted to women, liberal, proud, hasty, and yet sometimes very gentle." He wrote love poetry under the pen name Muhibbi and remained devoted for many years to a Ukranian concubine named Roxelana, whom he married. In one poem, he describes Roxelana, who took the name Hurrem after her conversion to Islam, as "My sheer delight, my revelry, my feast, my torch, my sunshine, my sun in heaven;/ My orange, my pomegranate, the flaming candle that lights up my pavilion." Often called the Lawgiver, Suleyman codified and simplified a complex and confusing array of legal procedures. His code attempted to wipe out discriminatory practices against Christian subjects and eased the draconian punishments against criminals.

But his reign had a dark side as well. Although the killing of rival brothers had long been a practice among sultans, Suleyman executed two of his sons as potential threats and often ordered the slaughter of prisoners after battle. He was a haughty ruler who started the sultanate tradition of refusing to say a single word when foreign ambassadors presented their credentials.

The exhibition includes Suleyman's throne, sword and tughra. The walnut-and-ebony throne, which Suleyman used on battle campaigns, is constructed so it can be taken

HADIYE CANGÖKÇE

apart and reassembled. Decorated in ivory and mother-of-pearl, the throne would be fitted with carpets and cushions so that the sultan could sit cross-legged upon it. The sword, known as a *yataghan*, is an exquisite example of Ottoman craftsmanship, its steel blade and ivory hilt lavishly decorated with gold and jewels. Suleyman's tughra is shown in an eight-foot-long illuminated work by the 16th-century artist Kara Memi.

Turkish scholars seem defensive about the Topkapi harem, mostly because of the titillating and fanciful accounts by ill-informed travelers over the centuries. It is, of course, difficult to break the popular erotic image when historians relate stories of Sultan Murad III passing between two lines of concubines and tossing a handkerchief at the one he fancied for the night. In the late 16th century, Sultan Selim II could choose from 150 concubines guarded by the 18 African eunuchs who ran the harem.

Scholars, however, regard the harem as a vital system of organizing the empire. Although the women were mostly non-Turkish slaves, either offered as gifts by their families or captured, they were well educated and lived in fine apartments with many servants. If they became favorites of the sultan, they wielded influence. If one's son became sultan, she assumed a powerful position in the palace. Despite their status as slaves, these women had some choice in ordering their future lives. Favorites who failed to produce a son could marry the highest officials of the empire. Those who never became favorites could accept an influential servant's job in the palace or a proposal of marriage from an outsider.

Topkapi scholars do not know which furnishings fit which rooms of the palace, but the array of carpets and curtains and bedding and cushion covers and tiles in the exhibition offer a hint of the sumptuous life within the mysterious harem. Some featured carpets are known as Lotto and Holbein carpets because carpets with similar patterns appeared in the paintings of Lorenzo Lotto and Hans Holbein the Younger during the 16th century.

Portrait of Mehmed II, founder of Topkapi, was painted for a 16th-century manuscript. Rock-crystal canteen (top) is from the 17th century.

The Topkapi Palace employed scores of artisans and was the center of Ottoman art. In 1575, for example, the palace enlisted 898 artisans. According to recent research by Filiz Cagman, they included painters, designers, tile makers, calligraphers, book binders, manuscript illuminators, goldsmiths, engravers, swordsmiths, bow and arrow makers, carpet and textile weavers, armorers, gunsmiths, furriers, ivory craftsmen, musical instrument makers and potters.

The new exhibition offers some of the finest examples of their work, much of it heavily jeweled. The best known is the Topkapi dagger, its sheath studded with diamonds, its hilt displaying three giant emeralds; a fourth emerald, at the top, conceals a small watch. Sultan Mahmud I ordered the dagger as a gift for the shah of Persia in the 18th century. The shah, however, was assassinated before Ottoman envoys could deliver the gift. Another example is a 16th-century sultan's pen box encrusted with jewels.

Some sultans chafed under the strict ceremonial rules of the Topkapi, and dissatisfaction with the palace intensified as the rulers became more Westernized and envious of their counterparts in Europe. In the 19th century, Sultan Mahmud II deplored the comparison of the Topkapi to Western palaces. "None save a rogue or a fool," he said, "could class that palace . . . hidden beneath high walls, and amid dark trees . . . with these light, laughing palaces, open to the free air, and pure sunshine of heaven."

The Topkapi Palace was abandoned in 1853 for the new Dolmabahce Palace. The sultans lived there while their empire and dynasty disintegrated—dismantled by British, French and Italian imperialism, nationalism in Greece and the Balkans, wars with Russia, an alliance with the losing side in World War I, and the creation of the Turkish republic by the war hero Ataturk in 1923.

The Dolmabahce was all that the Topkapi could not be. It was a monumental, three-story symmetrical building, with 285 rooms, 43 salons and an enormous reception hall. But the Dolmabahce suffered from a vital lack. It had none of the mystery and charm and history of the wondrous Topkapi.

Frequent contributor Stanley Meisler has written most recently on the new National Gallery of Art sculpture garden and John Singer Sargent.

HADIYE CANGÖKÇE (2)

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BY BRUCE WATSON

"you gotta remember, eels are weird"

THEY'RE SLIMY, SNAKY, UGLY AND REPULSIVE, BUT ONCE YOU ACQUIRE A TASTE FOR THIS MUCH-MALIGNED SPECIES, "SLIPPERY AS AN EEL" BECOMES A COMPLIMENT

As he fuels his 25-foot open boat on a rainy morning in Newport News, Virginia, Maurice Bosse prepares to haul in the makings of a feast. Like other fishermen plying their trade today, he could soon catch enough crab and bass to make a hearty chowder. But instead, like his father and grandfather before him, Bosse has baited his traps to haul in the ugliest, slimiest, most disgusting delicacy in the James River. Starting his outboard motor and steering into a bitter November wind, he begins another day of eeling.

On a good day, he says, he might catch 400 pounds of slippery eels. At $1.80 a pound, he will sell every one to his father, who runs the family's seafood business along the Potomac River. "If I didn't sell them to my dad, he'd kill me," Bosse jokes. Yet lately, there haven't been too many good days of eeling. One catch might total 200 pounds, the next a mere 100. Then, just when he's about to call an end to eel season, Bosse will haul in 300 pounds and decide to bait his eel pots for another week. "You gotta remember," he tells me in his amiable Virginia drawl, "eels are weird." I promise to keep that in mind.

Ten minutes' motoring brings us to the broad middle of the James, where a dozen small buoys bob. Pulling alongside one, Bosse hooks it and wraps the rope around the drum of an electric winch. With a quick whirr, the winch hauls up a black wire cage that seems to be alive. Inside it is a slithering mass of eels, white on the bottom and exactly the color of the murky river on top. "Hey, look at that," Bosse says. "Y'all brought me luck." After tossing a few delicious crabs back in the water, he dumps his repulsive catch into a plastic bucket. He tears a bait fish in half, stuffs it in the trap, dumps the cage overboard, then motors on and hooks the next buoy. Another ten eels slide from their cage. A third pot holds half as many, then come several with one or no eels. Finishing this part of the river, we head upstream to check more pots. But then, like a teenager drawn to a horror movie, I get an urge to touch one of those creatures Bosse has captured.

Slowly, I creep up to the eel bucket and peer in. Along the bottom, dozens

Eels as meals (opposite) may not be everyone's dish, but that fate lies in store for most of the creatures emptied from traps hauled by Maurice Bosse.

of dark, sinuous bodies slip and slide. Like snakes in a pit, the eels move over, under and through each other. A head or two slinks skyward. Ink-dot eyes search for an escape. "I'm going to do this once," I tell Bosse, "and then never again." I bend down and touch. "Slippery as an eel" is no mere cliché. As I squeeze one, its icy body slips through my palm, leaving a thick coating of mucus.

Poet Ogden Nash summed it up: "I don't mind eels/ Except as meals./ And the way they feels." Yet from the South Pacific to Scandinavia, eels have been studied, worshipped, farmed, even raised as pets. In Europe and Asia, they are regarded as a delicacy, served smoked, grilled, roasted, raw with rice at Japanese sushi bars or baked in pies at London pubs. In 1997, international demand spawned a frenzied black market in baby eels on our own Atlantic Coast. For this and other reasons, some species are getting harder to find, yet the eel still amazes those who do find it. Wide-mouthed morays lurking in Caribbean coves seem the embodiment of sea serpents. The freshwater eel, *Anguilla*, has a life cycle that rightly belongs in nature's *Believe It or Not*. Eels perform amazing feats of survival. They can emerge from water to wiggle through grass, slither out of certain strangleholds, sometimes even climb concrete dams. Once you get to know the species, "slippery as an eel" becomes a compliment.

Aristotle knew a thing or two about nature, but when he wrote his *History of Animals* in 350 B.C., he got the eel all wrong. An eel slit open by a knife revealed no egg or ovary, hence, the philosopher reasoned, eels did not breed at all. It was a logical conclusion. Hadn't he seen baby eels sprout from muddy ditches after a rain? "Eels are derived from the so-called 'earth's guts' that grow spontaneously in mud and in humid ground," he concluded. What Aristotle did not know is that eels' mucus, excreted from special glands in their skin, allows them to survive out of water much longer than other fish. They can bury themselves in mud to outlast a brief drought, then come to life when water returns. But Aristotle would not be the last naturalist to err about eels. Four centuries later, Pliny the Elder maintained that eels bred by rubbing themselves against rocks, scraping off scales that came alive. In Pliny's Rome, eels were kept as pets in shallow channels flowing into courtyard ponds. For Romans who drank too much, Pliny had a simple hangover cure—two eels, drenched in wine.

As aerated water is drained from a holding tank, eels slither around a workman's boots at a distributor's plant in Virginia. Soon they'll be on their way to Europe.

Fanciful roles were assigned to eels all over the world in creation myths, monster tales and folklore. They turned into handsome princes and even sprouted into coconut trees. But the truth about them has always been stranger than legend.

Eels are found in both fresh and salt water, and in nearly all parts of the globe. Theirs is the most diverse habitat of any fish. Yet few people ever come face-to-face with them. "They're cryptic critters," says Alex Haro, an ecologist in the Biological Resources Division of the U.S. Geological Survey, in Turners Falls, Massachusetts. "To actually see an eel in the wild is next to impossible." There

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LYNDA RICHARDSON

are only 16 species of freshwater eels, but the census is complicated by numerous "eel-like" creatures bearing the name. There are the true eels: morays, thread eels, worm eels, European eels, American eels, Atlantic marine eels, conger eels, snipe eels, garden eels, gulper eels and slime eels (a redundant name if ever there was one). Then there are also wolf eels, tiretrack eels, Asian rice eels and every aquarium's "must see," the electric eel. Yet these are eels in name only. Even the 600-volt electric variety, found only in the Amazon River, is not a real eel but a relative of the carp. "Any long, slinky fish has usually ended up being called an eel," says Kenneth Tighe of the Smithsonian's National Museum of Natural History. "But all true eels are marine at some point in their lives. And they all have an unusual larval stage." Eels are also distinguished by a one-piece tail fin that wraps around the lower half of the body.

But to be an eel, you also have to live the life. For anguilla, the eels commonly found in rivers, the life is one of hard travel. For morays and congers found in salty seas, life means hiding, hunting and scaring the bejeezus out of inexperienced scuba divers. Kevin Colter has been diving for more than 30 years, but he will never forget his first close encounter with a moray. At a depth of some 60 feet, near the Bahamas, Colter was "just swimming along," minding his own business. He peered into a hole in the coral reef, and there lurked a monster—flat-headed and olive green with gaping jaws and needle-sharp teeth. "I remember looking at those teeth for a while," he says. "I realized that if he wanted to, he could do some damage. But he didn't." Widely thought to be vicious, morays are actually very shy. Divers often hand-feed them, taking care to keep their fingers out of harm's way. Yet even a veteran diver feels his nerves quicken when a moray comes out of its cave. And comes out. And eight feet later, is still coming out.

"Once when I was young and foolish, I was feeding an eight-foot green moray some bait," says Colter, who manages a dive shop, Amigos Del Mar, in Cabo San Lucas, Mexico. "He realized the bait came from the bag I was holding. He came up between my legs and started to go for the bag, so I tossed it away from me, and luckily, he swam off after it."

As a diver and the curator of fish at the National Aquarium in Baltimore, Maryland, Jim Anderson has met hundreds of morays. He warns me that they often disappoint visitors, hiding during the day and only coming out at night. "Let's see if anybody's home," Anderson says as we approach the aquarium's moray tank. A huge grouper is hard to miss, but the green moray is nowhere to be seen. Suddenly a jaw juts above a rock. Two white eyes follow, and then a mustard-colored ribbon as long as a man undulates its way into view. Opening and shutting its jaws, something all morays do to pump water over their gills, it is the scariest-looking thing I've seen outside of a Grateful Dead concert. Morays won't attack you. They're not vicious, I have to remind myself. Then Anderson tells his story.

A few years ago, he was out diving on a reef. Not thinking about what he was doing, he reached into a crevice where an eel resided. When its jaws slammed shut on his fingers, it was like being hit with a hammer. "It was the classic thing you are told not to do. It was stupid. The first rule of diving is, don't stick your hands where you don't know what's there." Although he needed nine stitches, at least the moray let go. Anderson had heard of other cases where the diver's only recourse was to kill the eel.

Contrasting with the tenacious moray are gentle garden eels, which look like question marks sticking out of the sand. With tails buried in the ocean floor, a garden of such eels sway with the current, gathering plankton or small fish passing by. At the slightest disturbance, the eels duck back into their holes. In studying garden eels, Jacques Cousteau's divers played hide-and-seek. Cousteau's crew swam near. The eels hid. The divers swam away. The eels snaked out of their holes again. In, out, in, out. The divers tried using a pump to suck the eels out of their homes but found that the holes were tightly sealed with mucus.

All eels are born in the ocean, but only some stay there. Anguilla make a long journey to fresh water, living a salmon's life in reverse. Every schoolchild knows that salmon are anadromous; that is, they are born in rivers, swim to the sea, then return to the rivers, fighting their way upstream to spawn. But anguilla are catadromous, moving from salt water to fresh and back again. For eels in the Atlantic Ocean, the story starts in the Sargasso Sea (SMITHSONIAN, November 1998), the deep, clear water just east of the Bahamas. No one has ever seen eels mate or lay eggs. Scientists only know that each February and March, at depths of about 1,000 feet, eel eggs hatch into larvae resembling tiny leaves with pinheads. These future eels, transparent and less than half an inch long, look nothing like their parents. For centuries, scientists called them "leptocephali" and considered them a separate species. Then in 1896, two Italian scientists took some to their laboratory. They were astonished when the creatures turned into eels. Measuring them, comparing location and size, another scientist pinpointed the Sargasso as eel breeding grounds and began tracing their travels.

Eel larvae go with the flow. The whirlwind of currents surrounding the Sargasso disperses them throughout the Atlantic, from Greenland to the tropics. One species floats on the Gulf Stream to East Coast estuaries, where it was once harvested for native meals. Indians smoked their eels. Thoreau watched fishermen catch them in Walden Pond, and Walt Whitman wrote of taking "my eel-basket and eel-spear" out to catch dinner. But not all anguilla settle in American rivers. Another species drifts on the North Atlantic Current, floating all the way to Europe and then south to North Africa. Depend-

Metamorphosis of the eel

ing on their destinations, eel larvae migrate from one to six years. During that time, scientists believe, they subsist mainly on plankton. When they finally reach coastal waters, eels undergo a metamorphosis as miraculous as any caterpillar's. They lengthen, fatten and become glass eels, snakelike but still transparent. Swimming into rivers and streams, the glass eels turn smoky gray. In this phase, eels are called elvers, and at times they've been one of the hottest fish on the market.

During the spring elver season in 1997, nearly 15,000 pounds of elvers had their migration cut short by nets strung across streams along the Atlantic Coast. In the five Atlantic states where elver fishing is legal, a single pound of elvers sold for up to $400, but prices went up to $3,000 on the black market. Shipped live to East Asia, the precious catch was raised in eel farms, then eaten.

Eels as meals? Surely there must be something better on the menu. Yet eel enthusiasts know that the creatures aren't as disgusting on your plate as in your hand. The Japanese eat eel with a mystical reverence. Each summer, Tokyo restaurants swarm with diners hungry for grilled *unagi*. The delicacy helps cure summer blahs, so it's said, and can even restore failing health. When Tokyo sizzles, chain restaurants called "eeleries" slice and grill up to 10,000 eels a day. In this country, eel is available at any Japanese restaurant, so one evening not long ago I took my wife to Ichiban near our home in Massachusetts. I ordered the eel sushi and an eel roll. My wife played it safe with chicken tempura. Before you could say unagi, my eel was served.

Laid across a glob of rice, the eel looked like any other filleted fish. I took a deep breath and tried to forget "the way they feels." I sipped some sake, then closed my voracious jaws on my first eel. It tasted like . . . chicken. And fish. Fatty like fowl, yet almost as light as fish, and not bad with soy sauce. On the way home, I bought a tin of roasted eel, packed in Taiwan, but this proved as oily and disgusting as sardines. Only my cat found it tasty. Now, although I don't make eels part of my steady diet, I do enjoy them in exotic cuisine. In Spain, elvers are cooked into omelettes. In France, they are used in pâtés. It's said Babe Ruth liked to eat his eels pickled and smothered in chocolate ice cream, but I think I'll stick with soy sauce.

If an elver is slippery enough to elude fishermen, it heads farther upstream to metamorphose through two more stages. First, elvers turn a brownish yellow. Making salmon look like slackers, yellow eels surmount unbelievable obstacles. If land blocks their upstream journey, they can slither out of water and across grass, and slip through almost any opening. They have even been seen climbing small dams, using their mucus to stick to concrete, but this doesn't happen often.

It begins in the Sargasso Sea, where the American eel spawns. Larvae (far left) drift on the ocean current until they become transparent and about two inches long. During winter and spring, these glass eels (center) ascend rivers where they turn yellow and grow as long as a yard. Yellow eels, which can travel overland (left) as well as underwater, eventually return to the ocean as silvery, mature eels to start the cycle over again.

A mature eel bites a shrimp. When they can't swallow their prey whole, eels dismember it by tearing, twisting and pinwheeling around.

Once they find a comfortable place upstream, eels grow to maturity, reaching as much as a yard in length. Hiding by day and hunting by night, they eat anything they can swallow whole, even smaller eels. Standard fare includes crustaceans, insects, snails, plankton and small fish. If an eel can't gulp its food, it will tear into it and pinwheel around. The creature has been clocked at up to 14 revolutions per second, truly the "twirly-whirly eel" Rudyard Kipling noted in his *Just So Stories*. Finally, after spending 10 to 23 years upstream, there comes a time in late summer or early fall when aging eels get the urge to go home again. Undergoing a final change, they turn silver and their eyes enlarge, all the better to see with when they return to their deep spawning grounds. Swimming downstream, they cross the Atlantic until they reach the Sargasso. There, hidden safely from view, they spawn and die. It's a living.

In Maurice Bosse's family, eeling has been a living for three generations. Bosse, now 27, took to the trade as a boy, setting pots in a creek near his Virginia home and hauling in 70 pounds of eels in an afternoon. He sold them to Robberecht Seafood, started in the 1960s by his grandfather. At one time, Robberecht sold only eels, shipping them live, packed in ice, to European markets. The business has since added other catch but still handles 200,000 pounds of eels most years. Yet something funny is happening to the slimy staple of the family business. "Eels are sure getting scarce," Bosse told me. "We used to bring up pots so full there'd be mesh marks on the eels' skin from being jammed together against the cage. Then about six years ago, it was like someone came in the river and flushed all the eels out. Ever since then, it's been less and less."

No one is sure what is happening to the American eel, but the numbers are not good. From wherever they were once abundant come stories of sudden scarcity. When Britt Gilbert began running the Burnshire Dam hydroelectric project in Woodstock, Virginia, folks in the small town had a saying about eels. Each fall, when eels headed down the Shenandoah River, they clogged the power plant's turbines, causing local lights to flicker. People would nod and remark, "Must be an eel in the wheel."

By 1982, after Gilbert took over the plant, it had been hooked to a regional power grid, so eels no longer dimmed the lights. Yet Gilbert will never forget the first time he heard his powerful turbines grind to a halt. "I crawled down into the dark, dank room beneath the level of the river," Gilbert told me. "I reached into the turbine case and felt this cold, wet, dead thing. I let out a shriek. I thought it was a human body caught in there. But it was eels." For a few autumns, Gilbert hauled buckets of mashed eels out of his turbines. Their tough, mangled skins were "like nylon stockings stuffed with beef." Then came a fall when fewer eels got tangled. And by the time the plant closed in 1989, he said, the eels were gone.

The hard data on North America's eel decline confirms Gilbert's observation. In 1983, more than a million eels came through an "eel ladder" along Canada's St. Lawrence River. By 1992, the number was fewer than 12,000. Why the 99 percent decline? Pollution? Some was measured, but researchers concluded it was not enough to wipe out the hearty eel. Too many dams blocking their passage? By some estimates, 84 percent of eel paths along East Coast rivers are now dammed, yet most of those obstacles were constructed way back in the 1950s—too long ago to explain a sudden decline 30 years later. Too much eel fishing? The catches had not increased in decades. Global warming? Probably not. Oceanographic changes that occurred in the 1970s in the Gulf Stream, which is the beltway for distributing North American eels from the Sargasso Sea, caused little population change in the St. Lawrence. Researchers reasoned, therefore, that any similar changes due to global warming in the Gulf Stream in more recent years would not account for the decline in eel numbers. The answer may lie at any point along the eel's 6,500-mile migration route, but one thing is certain. As eels became scarce in the 1990s, demand created what many called "a gold-rush mentality," especially in Maine.

On a dark spring night in 1997, a new crop of elvers drifted ashore near West Boothbay Harbor along the Maine coast. Waiting for them was a lone fisherman. And waiting for him, with a citation for illegal elver fishing, was the Maine Marine Patrol. With a license, the poacher could have legal-

PAULO DE OLIVEIRA/PLANET EARTH PICTURES; P. 128, 129 PAULO DE OLIVEIRA/PLANET EARTH PICTURES; YOSHIHEI SAKAMOTO/NATURE PRODUCTION; JOHN LYTHGOE/PLANET EARTH PICTURES

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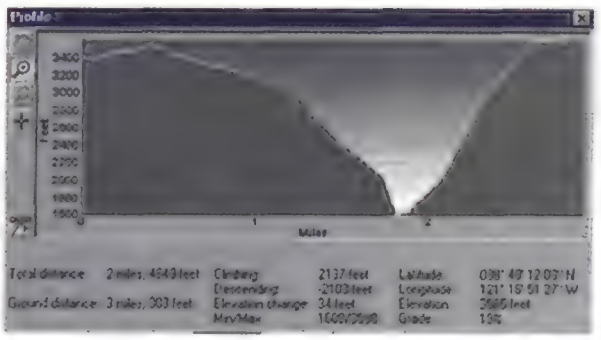

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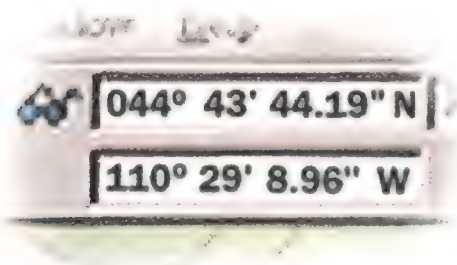

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Bringing its huge wings into play, a great blue heron struggles to maintain its grip on a thrashing eel it has plucked from the shallow waters of a rocky seacoast.

ly caught elvers in streams, but he knew there were more of them traversing the fishway over the dam, and went to great lengths to break the law against fishing there. First, he searched all over for Marine Patrol vehicles. They were well hidden. Then he asked nearby residents if they'd seen any officers. Finally, he dipped a dummy net, a hoop with no mesh on it, to draw out any lurking officers. If caught, he wouldn't really be fishing. But officers were not fooled. When the fisherman got out his real net, elvers swarmed into it and the officers closed their own trap. In just three minutes, before being arrested, the fisherman had caught $1,000 worth of elvers.

In 1997, elver fishermen in Maine strung nearly 4,000 nets across storm drains, rivers and streams, and those were just the legal nets. Authorities that year likened the elver black market to the drug trade. When prices skyrocketed in 1995 in response to dwindling numbers, a clandestine network of dealers began trafficking in parking lots and rest stops along Interstate highways. As with the drug trade, tempers and turf wars flared.

Maine reacted by tightening licensing requirements and imposing more limitations on gear. But what took the boom out of the black market was a sudden change last spring in the eel situation overseas. Thanks to some successful aquaculture ventures and an unexpectedly high eel catch in Europe, China and Japan, the worldwide supply increased, prices fell and elvers weren't so hot anymore.

What to do about the continuing eel decline here? Last spring the Atlantic States Marine Fisheries Commission released its first eel-conservation plan, mandating strict monitoring of the eel catch along major rivers. Others are helping eels surmount dams. Starting in May, when elvers migrate upstream in Maine, Gail Wippelhauser gets out her portable eel passages. These wooden ramps, placed around small dams, can secure travel for several thousand eels in a single night. "We're not sure what's causing eels' decline, but better passageways can only help," says Wippelhauser, who is the manager of the American Eel Project, run by Maine's Department of Marine Resources.

Anguilla face a future as uncertain as the eel Father William balances on his nose in *Alice in Wonderland*. Many are working for the eel, but its reputation works against it. "Unfortunately, eels don't inspire much sympathy," Alex Haro says as we wade into a concrete holding tank near his Massachusetts lab. Lurking in the black water—somewhere around my legs—are two American eels. Haro walks to a corner of the tank and lifts a plastic pipe. The eels slide down it and into his net. The captives twirl around each other, seeking the nearest hole. But there is no escape, so I reach down for one last feel of the elusive, eerie eel. These two will be tagged for tracking and released back into the Connecticut River, Haro says. They'll swim upstream again, feed for a few more years, then head home to the Sargasso. I wish them luck. I don't mind eels anymore, not even as meals. And as to "the way they feels," I can only hope they grow even slimier. In a world filled with fishermen, dams and diners, one has to be slippery to survive.

Bruce Watson wrote about the Army-Navy football game in the December 1999 issue.

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Day by Day, in Pursuit of Justice

IN WASHINGTON COUNTY, VERMONT, PROSECUTORS FACE MOUNTING CASELOADS, LOOMING DEADLINES—AND ONGOING DRAMA

BY RICHARD & JOYCE WOLKOMIR

A woman is screaming.

It is after midnight, a small town. But many in this low-income apartment complex peer out: she is on the macadam, rolled into a ball. A man kicks.

Out of the darkness, a big fellow. He confronts the kicker. Fists. Bodies thud onto the macadam. The woman is gone. The kicker runs.

Siren.

The big man runs, too. A cruiser rushes in, blue lights flashing.

"Arrested, lodged." Terry Trono reads aloud. He is scanning one of the files from this morning's heap on his desk. " . . . felony aggravated domestic."

He spreads out the arrested man's record. It runs to five printed pages. But he remembers most of it from previous encounters. "When was it? 1986?" he says. "Vince attacked two pic-

ILLUSTRATIONS BY CAROLYNE D. LANDON

In district court, State's Attorney Terry Trono delivers an argument as the presiding judge looks on.

Currently, 300 cases are backed up. Even so, Terry Trono and his four deputies take on some 40 new cases every week, around 1,800 cases a year.

nickers with a lead pipe—he served most of ten years on that one."

Trono is slight, prematurely gray, alert, sociable. He is state's attorney for Washington County, Vermont—the prosecutor. He began here as a deputy in 1977, fresh from law school. He was elected state's attorney in 1982. He has been reelected every four years since. By now, he knows many of the names in these files heaped on his desk mornings. Or he may, in court, have met the defendant's older brother. Or father.

Second-Degree Aggravated Assault, Domestic. That is the first count the arresting officer filed. On the folder it is abbreviated "2nd AgA(D)." Count Two is Violation of an Abuse Prevention Order ("VAPO").

Currently, 300 cases are backed up. This county's towns are small, even the state capital. It has mountainside farms, granite sheds, state offices, insurance companies. Crime rates are low. Even so, Terry Trono and his four deputies take on some 40 new cases every week, around 1,800 cases a year, plus fish-and-game violations and moribund cases revived, and about 400 juveniles. Most cases go to District Court, downstairs—it has only one judge. Budgets are so tight that to get funds for DNA tests, prosecutors must "beg and whine." But crime is a bull market: each of this office's five prosecutors at any time has some 100 cases in play. This morning they are working on a burglary, pedophilia, heroin dealing, a 3-year-old foster child burned, drunk driving, a rape, bad checks . . .

"Let's see what the police have to say." Trono skims the affidavit filed in the state capital by the arresting officer. "A 911 complaint," he reads. "Vince assaulting his girlfriend, who is also the mother of his infant daughter." The officer arrived at the Cummings Street apartment complex at 12:34 A.M. "Vince had punched her in the face," Trono reads. "Next, she claims, he threw her down to the ground and kicked her head." A man she did not know intervened. She escaped. At 2:54 A.M., she called 911 again—Vince was back, knocking on the door. "Vince then tells the police that she 'spazzed out' and hit him, which caused the injury to the back of his head . . . "

Trono looks faintly wry. "Looks like Vince is going for a self-defense angle," he says.

Now he scans the officer's affidavit for witnesses, his yellow marking pen poised. But he finds nothing to mark. "She went to a neighbor's to call police—but which neighbor? He does not say. No telephone number here."

Exasperated, he scribbles a note to the officer: "Appear to be a number of witnesses with no names disclosed . . . " For instance, he points out, Vince had a bleeding neck and a possibly fractured wrist. Police transported him to the hospital emergency room. But which doctors and nurses treated him there?

"Tronograms," the police call these notes. They go out, Trono says, because officers can arrest or cite if they have "probable cause" to believe someone committed an offense. But prosecutors must convince each of 12 jurors that the accused is guilty "beyond a reasonable doubt," a higher standard. Trono needs actual witnesses. But he has no authority over police. And so his Tronogram ends on a plaintive note: "Vince is a serious offender. Did 5-10 years on agg assault. . . . This request is certainly worth doing."

Next he checks the two charges the

Trono (standing) and deputy prosecutors (from left: Paul Finnerty, Anne Whitten, Stephanie Ilberg and Tom Kelly) convene to discuss the massive caseload.

Mrs. Brown's class is all ears.

In Woodburn, Indiana you're never far from oceans of corn. So Helen Brown decided to teach her first grade science class an in-depth appreciation of their state's most important crop.

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This demonstration leads to discussions of environmental issues, such as trash disposal, recycling, biodegradable products and loss of farm land due to population pressures. Pretty advanced stuff for a group of first graders.

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arresting officer filed: violation of an abuse prevention order and second-degree aggravated domestic assault, a felony. Trono looks up the applicable law, 1044-a-1. A judge had previously prohibited Vince from abusing his girlfriend. But that was a *civil* order. For a felony, he would have to violate a *criminal* court order. Also, there was no deadly weapon, no serious injury.

"We'll amend it to a misdemeanor," Trono says. Now the docket will read "SA(D)," meaning Simple Assault, Domestic.

His telephone rings. It is Vince's girlfriend.

"This has happened several times and nobody's done anything about it yet," she complains. She says she does not know the big man who intervened. But she offers names of neighbors who saw the incident.

She and Vince had broken up and were living apart. Vince called, asked her to open the apartment because he had nowhere to stay the night. "Vince was drunk and starting in with me," she says. Their 6-month-old daughter was inside the apartment. "He'd locked the door so I couldn't get back inside to my daughter," she says.

"Will he be let go today?" she asks.

"It's fifty-fifty," Trono tells her. "At the very least, he'll have orders to have no contact with you."

After hanging up, he leaves voice mail for his office's investigator: visit the Cummings Street apartments, get witnesses' statements. As he talks, he is pulling on his suit jacket, gathering up files to head downstairs, to court.

Larry Dodge, a detective assigned to the State's Attorney's Office, interviews a victim.

DISTRICT COURT, JUDGE ALAN CHEEVER PRESIDING

"BE SEATED."

Judge Cheever speaks softly. Even black-robed, ensconced up high at the long and imposing room's wood-paneled far end, he is a benign presence.

Most defendants walk in from the street, through the metal detector and then through the courtroom's main door. But some enter through a back door, escorted by sheriffs, handcuffed. They shuffle, ankles chained. That is how Vince arrives, glowering.

He is not tall but rangily muscular, with short, shaggy dark hair, a weathered face, unshaven. He wears a red sweatshirt, white shorts, high-top sneakers; his head is wrapped in a white bandage, and one wrist is in a cast. He stands at the defense table with his court-appointed public attorney. At the prosecutor's table, Deputy State's Attorney Anne Whitten, a former FBI agent, green eyes sharply focused, leafs through the file. With so many cases gushing in, prosecutors often must familiarize themselves with the details in the courtroom.

"He has a serious criminal record, going back to 1978, Your Honor," Whitten says. "He served the majority of a five-to-ten-year sentence for assault. And we are concerned about nonappearance because his most recent felony conviction actually was a felony escape."

Whitten seeks cash bail. Vince's public defender objects, arguing he has strong local ties. "He'll be starting tomorrow as a laborer on road maintenance," the defender argues. "And he's never actually missed a court date, even when he was facing serious offenses, and facing serious time—here he stands charged with just two misdemeanors, and there's substantial likelihood he'll appear at trial, and he'll be living with his father."

"These are troublesome issues," Judge Cheever says. "His prior history. And his conviction for escape is troublesome."

But the judge releases Vince.

He must stay in his father's apartment, except when working. He must keep 500 feet from his former girlfriend and witnesses. Vince shuffles off, escorted by the sheriff, to be set free. On his "Conditions of Release" order, the judge has noted that he is imposing strict restrictions because "the release of the defendant will constitute a danger to the public."

"Next case."

FELONY GROSSLY NEGLIGENT OPERATION, DEATH RESULTING

EIGHT 15- AND 16-YEAR-OLDS, IN A minivan, headed to a high school basketball game. The driver should not be driving—he has only a learner's permit. He took his parents' van without their permission. Some of the teens have been sipping beers.

Red light. He runs it. Tractor-trailer.

One girl is dead. All seven survivors are ambulanced. One boy is unconscious. For weeks his mother, a recent widow, stays by his bed. He dies.

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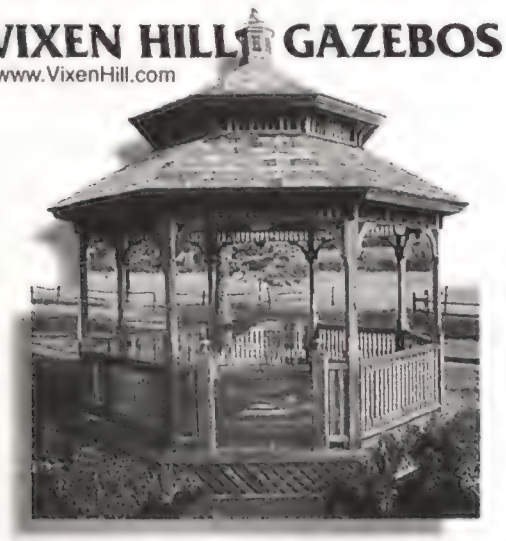

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Terry Trono seeks a grand jury's advice. The 23 citizens indict the driver on the most serious charge, a felony, grossly negligent operation of a vehicle causing serious bodily injury or death, deserving of up to 15 years in jail. The vote, however, is 13 to 10. In a trial, the verdict would have to be unanimous. Settlement is a possibility. But what punishment? Trono asks parents of the other kids in the crash. Not jail, some say. The dead boy's mother says jail. Trono is left to grapple alone.

THE VINCE CASE: WITNESSES

"Was she lying curled up on the roadway or on the sidewalk?" Larry Dodge asks, jotting notes.

"A little bit of both," says the woman, who is smoking a cigarette. Behind her, on her apartment wall, hangs a matchstick crucifix.

"Look like she was trying to avoid something?" Dodge asks.

"Avoid being punched in the face," the woman says.

Dodge is a Department of Public Safety detective assigned to the Washington County State's Attorney's Office. He is at the Cummings Street apartments, taking various statements that concern Vince's case. It is sweltering. In this cul-de-sac, kids swarm. Men in undershirts sprawl in plastic lawn chairs.

"He had brought his hand back, like he was going to hit her," the woman says, exhaling smoke.

Dodge stares at his notes, silent for long seconds. "You never saw him actually hit her?" he finally asks. Dodge wears a business suit and black cowboy boots.

"I heard a scream and a slap," she says. "Somebody grabbed him and started scrapping with him—I have no idea who it was."

Dodge gives her his notes. She looks at the pages blankly, drawing on her cigarette.

"Check that out," he says. "See if that's true to what you told me."

Her hands are shaking as she holds the papers.

"Do you need a little help with the reading?" Dodge asks.

After the woman has signed each sheet of her statement, Dodge crosses the street to photograph Vince's former girlfriend's injuries—a blackened eyelid, bruises, scratched arms. Vince blew up, she says, when he learned she wasn't going to stay in the apartment with him.

Dodge recrosses the street. Another witness to interview.

"I saw the last kick in the head, and it was a full-force kick," this woman tells the detective.

"A football kick?" Dodge asks.

"Yes," she says. And she saw the man with whom Vince fought. "Vince got thrown on his back a few times, real body slams," she says. She knows the man, she says. Definitely. She points unhesitatingly. "He lives right over there."

Dodge knocks on the indicated door. A woman opens it. She says her boyfriend was away that night. A moment later, the boyfriend appears. It wasn't him, he says.

He is of average height. And in this small town in northern New England, he stands out. He is black.

Several days later, at the court building, a probation and parole officer telephones upstairs to Deputy State's Attorney Anne Whitten: he has found the man who fought Vince. He was a furloughed prisoner. When the police came that night, the man ran because he was violating his furlough, visiting a woman in the apartments. "I saw him hit her in the face twice before I got to him," the man said. This man is a giant. His hair is Viking blond. Unreliable witnesses, it turns out, are simply an everyday occurrence for investigators.

UNLAWFUL TRESPASS

SHE STANDS LISTENING TO THE judge, dabbing a tissue to her eyes. A slight 23-year-old.

"The last thing I remember is being kicked in the head and seeing white light."

"Are you aware of the charge, unlawful entering?" Judge Cheever asks from his high seat. She nods.

At the prosecutor's table, Terry Trono reviews her records: from New York State, treated at two costly private mental institutions in Vermont. Now she cooks at a natural foods café.

She had once broken a mirror, purposefully cutting herself with the shards. An officer found her crouched in her closet, "crying much like a frightened child." She cut herself, she said, because she was "not pretty." Her boyfriend reported she had mixed alcohol and Prozac. At the police station, she kicked one officer in the chin. Now, drunk again, she broke into a neighbor's apartment. Police found her weeping inconsolably under her bedcovers.

"You had no reason to be in the other apartment?" Judge Cheever asks. "No," she says, her voice small. "Are you aware the state alleges that you engaged in fighting, threatening and tumultuous behavior?" She pleads no contest to contempt of court, and guilty to violation of probation and disorderly conduct.

Terry Trono has recommended an intensive substance-abuse program. Watching her leave the court, he says: "She's 99 percent mentally ill and one percent criminal." He shrugs. "But the best way to get her help is through the court system."

MEETING: VINCE'S VICTIM

"THE LAST THING I REMEMBER IS being kicked in the back of the head and seeing white light," she says.

Anne Whitten examines the blackened eyelid where Vince hit this young woman, and her bruised arms. The woman bounces an infant on one plump, bare knee.

It is 90 degrees today. Downstairs, the court is air-conditioned. But up here on the fourth floor, only rickety fans stir the steamy air. Terry Trono's corner office doubles as a meeting room. Its windows overlook Barre's red-brick downtown and the surrounding hills, where slag heaps mark granite quarries. The decor in these offices runs to dented gray filing cabinets, beat-up desks. New deputy prosecutors start at $24,000 per year. Each of the four deputies occupies a closet-size office. In this heat, the offices are stifling.

"What's the best way we can keep

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On the courthouse steps, defendants converge and wait. Most of this district's defendants are white males, 16 to 28 years old, many with substance-abuse problems.

you and the baby safe?" Whitten asks.

"Just keep him away from me, I guess," she says. "Now I'm 19 and I think to myself, 'What was a 35-year-old man doing, being interested in a 17-year-old?'"

This office has a victim's advocate. But Anne Whitten is meeting with the victim today because, as she puts it, "You hate to lose a case because the victim says that the prosecutor was not in touch."

"So, are you Vince's lawyer?" the woman asks. Whitten shakes her head. "Then are you my lawyer?" "No, I represent the people of the state of Vermont," Whitten says. "We regard this as a crime against the people of the state of Vermont."

RAPE, KIDNAPPING

THEY ARE LOOKING AT TWO WHITE-cardboard placards leaning against Terry Trono's office window. Over weeks of meetings like this, Trono has drawn a time line, in colored marker, onto the placards, with notations about evidence of the alleged crime: the moment—according to the victim—the young man broke into his girlfriend's mother's mobile home; the moment he accosted the mother—61 years old, heart condition, cancer; the moment she says he raped her; kidnapped her; drove her to a cabin in the woods; tied her up. Noted also is the moment she says she escaped; the moment she began trudging through the woods in three feet of snow, wearing sneakers, fearing to walk down the plowed dirt road because he might find her; the moment she reached a house; the moment the residents called 911.

Because this young man is a former high school basketball star, clean-cut, blond, good-looking, the prosecutors call him "the Princeton student." Actually, he is a laborer. Now, in prison, awaiting trial, he is sending letters to witnesses and to his former girlfriend and her mother, the victim, and getting friends to call them.

"We can't get in 'bad acts,' the criminal stuff a defendant has been charged with or convicted of, to show he's a bad egg, because the law does not allow it, so the question is, on the chart, how much to the left of the rape can we get in?" Terry Trono is saying. "Is his conduct before the event admissible?"

"How much detail on the previous assault on the daughter can we get in?" she asks.

"Look at his case history!" exclaims the state police detective. "Can't we at least show that she was afraid to walk the road out from the cabin, this old lady, in her condition, so afraid he would see her?"

"The defense will admit everything except the rape," Trono says. "They'll say she made it up. So other 'bad acts' are a big issue in this case, and we're doing a lot of research on that."

Anne Whitten is scanning a law book. "How much detail on the previous assault on the daughter can we get in?" she asks. Besides kidnapping and rape, Trono points out, they have also charged the defendant with lesser crimes, so at least they can inform the jury about the restraining order from the previous assault.

"So first he tied her up at her house?" Trono asks.

The prosecutors and the detective are trying to get straight on the use of various cords—cords used to tie the woman at her home, cords used to tie her at the cabin after her abduction, cords they have found, cords still missing. There was a blue telephone cord entangled with brown twine, a piece of yellow rope and a length of orange extension cord.

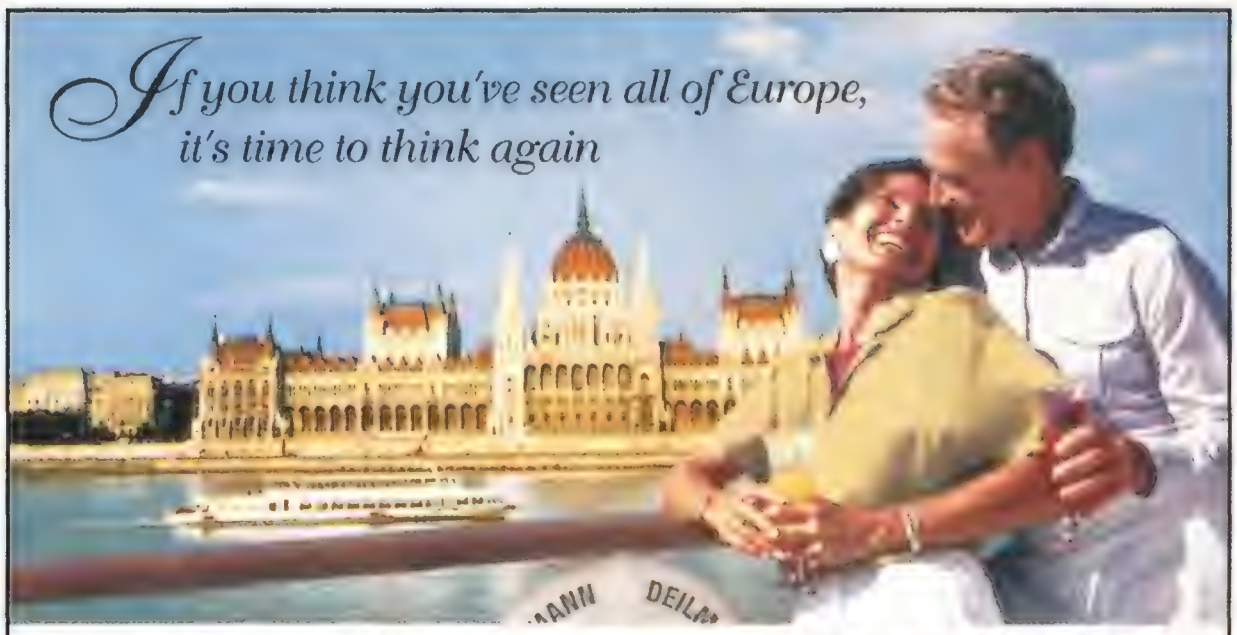
Anne Whitten: "Just imagine us trying to explain all of this to a jury!"

Terry Trono gazes at the intricate time line, shaking his head. "Half the jurors will think he couldn't have raped her because she's old, and sick, and not attractive," he says.

IN THE COURT'S ANTEROOM

DEFENDANTS SUN THEMSELVES ON the courthouse's stone steps, sipping coffee from Dunkin' Donuts cups, smoking. Ponytails. Sleeveless shirts showing off tattoos and weight-lifter arms. They talk.

"What they do is hit you with the



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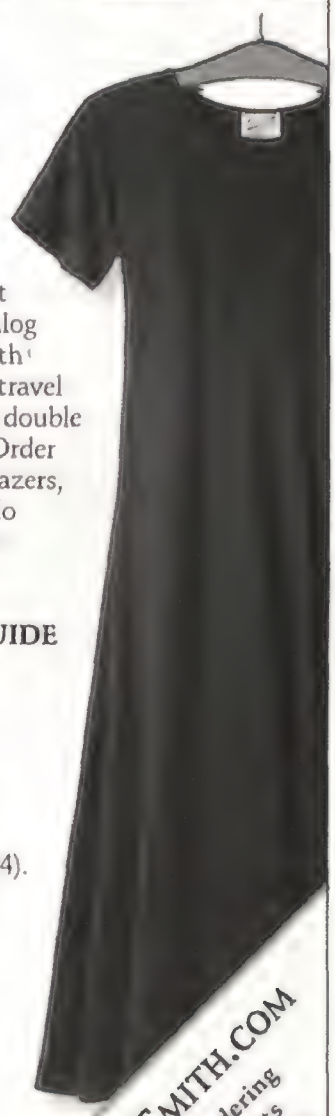

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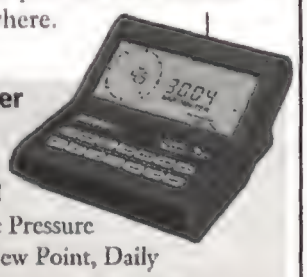

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Reenacting an arrest as they recall it, two troopers reconstruct a night's events for prosecutor Tom Kelly.

heaviest charge they can, so you have to pay a lawyer."

"Yeah, it's all about bucks."

"They're all in on it, from the governor on down to the cops."

Inside the courthouse, the crowd milling in the lobby embodies Terry Trono's estimate: most of this district's defendants are 16 to 28 years old, 98 percent are white males, and a high percentage are addicted to drugs or alcohol, and are so nearly illiterate they are virtually unemployable.

Attorneys carrying briefcases motion clients into cubicles. Many of the attorneys are public defenders—perhaps 60 percent of the defendants qualify because they cannot afford an attorney and they are charged with serious offenses. Prosecutors also use the cubicles, to make deals.

It frustrates Terry Trono that many citizens scorn such plea bargains as leniency. With more than 2,000 cases a year in this county, and a single District Court judge, only a fraction of the cases can possibly come to trial. About 90 percent of the defendants accept an "offer": they plead guilty in exchange for the prosecutor's seeking a particular sentence from the judge. In a trial, if the defendant loses, he might get the maximum sentence. For the prosecutors, key witnesses may prove unpersuasive, or physical evidence may be scant. Trono's goal is "to protect the community." That may mean jail. Or it may require merely separating the perpetrator from bad influences. Or it may mean maximizing restitution to a victim, requiring the defendant to work. Sometimes the prosecutor decides punishment outweighs restitution. Sometimes protecting the community means treating the perpetrator's drug or alcohol addiction.

Between courtroom stints, Trono cruises the lobby, talking with defense attorneys and police officers, even chatting, in his personable way, with some defendants he has previously sent to prison.

"Hey, Terry."

"Joe—what is it this time?"

"They got me on DWI, and I'm getting work crew."

"Could be worse."

Trono started life in Burlington, Vermont, his father the son of Italian immigrants, his mother descended from a long line of Vermonters. But he grew up near Albany, New York, where his father became a school principal. Of his four brothers, one is a urologist, one a hospital administrator, a third a labor-relations lawyer, and the fourth is also a prosecutor, in Richmond, Virginia. Trono graduated with a degree in psychology, and worked with delinquent youths in Rochester, New York. His contacts with police and the court system drew him to law school.

He became a prosecutor, at first,

because his wife was teaching in Washington County and he needed a job. But he thrived on the work.

Running for reelection every four years is stressful. He has little time to campaign. And voters could turn him out of office by chance, few really knowing how well he does his job. And it troubles him that many parents expect the court to provide "magic cures" for their out-of-control teens, at taxpayer's expense. But he has no yen for private practice. "A bank robbery turns out to be more interesting than a will," he says. Sometimes he comes in at dawn on Saturdays to work through files piled on his desk. But he likes to be "hopping and going." And he likes talking with all sorts of people.

In a cubicle, Trono relaxes in a folding metal chair, chatting with a 19-year-old—blond billy-goat beard, turquoise earrings. This boy, convicted once before of underage drinking and driving, has attended sobriety classes. But now he has done it again.

"How did you find the counseling?" Trono asks. "Not bad—I learned a lot." "Apparently not all that much," Trono says cheerfully. "But this time I didn't get drunk!" the boy protests. For adult drivers the legal maximum blood-alcohol content is 0.08. For drivers under age 21, this state requires automatic license suspension for a blood-alcohol reading that is above 0.02. This young man tested at 0.04.

"I did the counseling with older people in for drugs and alcohol, and I can tell you I won't be doing drugs!" the boy says. "Have you got a pen?"

Terry hands over his pen. This is a plea bargain—six more alcohol counseling sessions over two months, for which the boy will pay. "Yeah, that's a couple hundred dollars per beer," the boy says, signing. Amiably, Terry grins. "Your really boneheaded move was getting behind the wheel," he says. Amiably, the boy nods.

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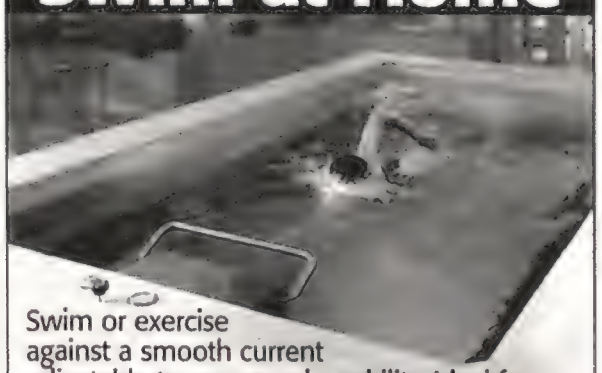

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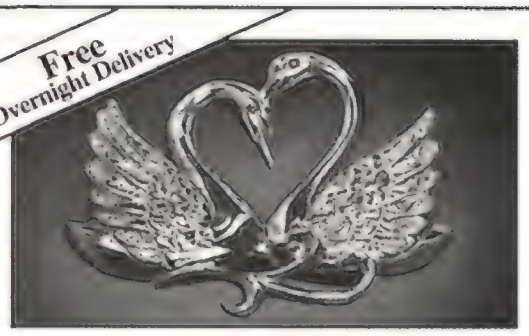

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VIOLATION OF CONDITIONS OF RELEASE

"VINCE HAS BEEN A BAD BOY," SAYS Deputy State's Attorney Anne Whitten, scanning affidavits as she waits in court for Vince to appear. Vince has been visiting his former girlfriend, violating his release conditions. He admitted flicking his lighted cigar into her new boyfriend's truck. "I love my child and want to have contact with my child," he said in his statement to the police. "I am not doing this to be mean or cause any problems."

Judge Cheever tightens Vince's release conditions. If he breaks them, he can be arrested without a warrant.

Later, Anne Whitten sends Vince's court-appointed defense attorney an "offer": plead guilty to simple domestic assault, violation of an abuse-prevention order and three counts of violation of conditions of release. Then, instead of jail, complete intensive substance-abuse and domestic-abuse programs. Alternatively, she offers Vince a jail sentence of six months to $3\frac{1}{2}$ years.

Whitten expects him to accept one of the two offers. With witnesses, he stands to lose at trial. The outcome could turn out to be another long stretch in prison.

TRIAL: CAIN AND ABEL

"WHY DID YOU CALL THE BARRE Police Department?" Deputy State's Attorney Paul Finnerty asks.

"Because my brother had attempted to run into my vehicle for the fifth time!" says the defendant, on the witness stand. He is a 47-year-old contractor. Glasses. Dark beard and hair, neatly clipped. Dark suit.

"Then why," asks Finnerty, "when the officer came to your house did you say that he was unwelcome?"

The contractor says: "Past experience!" He adds, "The Barre PD is not my friend."

This is the trial's second day. Two days too many, Finnerty thinks. Court time. Tax money. All because

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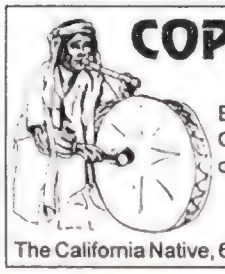

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middle-aged brothers feuded, the dark-haired defendant and his blond brother. And the feud turned dangerous. In this latest episode of the years-long fraternal spat, on a Sunday morning the blond brother—according to the defendant—drove by and gestured obscenely. Next came a Buster Keaton comic car caper, the defendant's pickup and his brother's car zigzagging through the streets. The defendant tried to videotape his brother. For years the two had been videotaping each other for "evidence." Next, Finnerty maintains, the defendant slowed his pickup to a near stop at the curb. As his brother passed, he floored his pickup's accelerator, forcing his brother's car leftward, until it plowed into a parked car. Finnerty has produced witnesses.

The court is nearly empty: judge, stenographer, court officer, jurors looking incongruous in polo shirts, some in shorts. At their table, the defense attorney and defendant confer. Finnerty sits alone. The spectators here are few: the defendant's wife and—across the room—his brother and sister-in-law.

Juries decide facts, but judges decide law. Often jurors sit reading novels or crocheting, or leave the room, while the prosecutor and defense attorney ask the judge to decide fine points.

This jury has heard the defendant and witnesses testify to the routes taken by the brothers in their crosstown chase. Elm Street's width at the crash site? Distance to the next intersection? The jurors have visited the scene. They have heard a private detective hired by the defendant to test his truck's acceleration. They have heard Paul Finnerty cross-examine the detective: "Isn't it true that your private detective's license has not been renewed because you in fact failed to complete a professional ethics course?"

Closing arguments are heard. The defendant's attorney begins his summation: "This is a case of perception."

Finnerty, in his final statement, offers his perception of events. "Something has been going on between these two brothers, and for many years," he says. "It doesn't matter." What does matter, he argues, is the defendant's behavior. Witnesses have testified to that. And there are discrepancies between his statement to the police, a few minutes after the accident, and his courtroom testimony. "*Res ipsa loquitur*," Finnerty says, translating the Latin: "The thing speaks for itself."

Four hours later, the jury declares the defendant guilty of grossly negligent operation of a motor vehicle. The penalty: up to two years in jail and a $5,000 fine. The taxpayers' cost? Paul Finnerty shrugs. A trial is a constitutional right.

TRIAL: THE MALLEABILITY OF PERCEPTION

IN THE PROSECUTORS' WARREN OF offices, two huge troopers wrestle with Deputy State's Attorney Tom Kelly. They are reenacting the circumstances of an arrest according to the troopers' recollection. The red-haired prosecutor is marathoner lean, not large. "So this is how you recall that you held his arms?" Kelly is asking the troopers.

January. Neighbors call the state police: late last night, a ski-resort snowmaker left his car blocking their mutual road. They prefer not to confront him, they say: he has guns. En route, the two troopers learn via radio an arrest warrant is out for the snowmaker. Previously, in a confrontation, he had been convicted of striking another driver with a tire iron. Now he is wanted for a probation violation: failing to report he had moved.

Later, the troopers will recall their version of that night's events. "I have a warrant for your arre . . . " one trooper starts to say, but the snowmaker begins slamming the door. A scuffle. The troopers haul him outside, throw him onto the snow, and finally cuff him. One trooper goes

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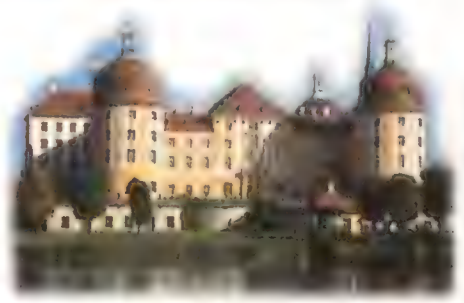

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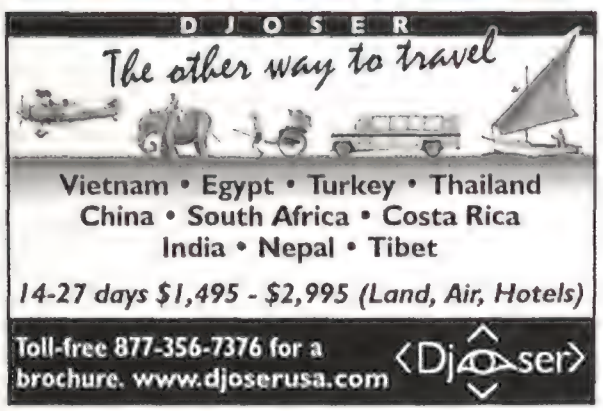
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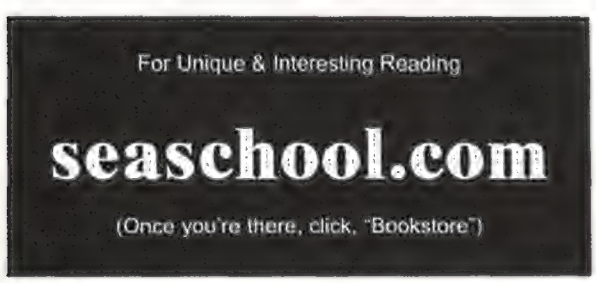

back inside to fetch the arrested man's keys, to lock up. On the kitchen table, beside the keys, he finds marijuana, a pipe and various other drug paraphernalia.

"I'll tell you right now, the jury is going to play legal scholar," Terry Trono is saying.

This case of resisting arrest and marijuana possession came to Tom Kelly with one day to prepare for trial. Kelly says the defense attorney asked prospective jurors whether a person has the right to resist arrest if the police officers have used excessive force.

Kelly works late, interviewing the arresting officers and the chemist who tested the marijuana, delving into previous cases of resisting arrest and the legalities of a trooper's opening a bag of drugs without a search warrant. "We never struck him," one of the troopers tells Kelly. "But the hard part is the jury will look at our size, and his size . . . " Terry Trono: "Jurors will say they didn't read him his rights—most of the damage comes from totally misguided information on TV cop shows, because people don't know you have to read them their rights only if they're in custody, being questioned."

At the trial, the snowmaker—bearded and longhaired when arrested—arrives clean-shaven, wearing a gray business suit. On the stand, he speaks softly. He knows a little about arrests, he says: once, he saw his roommate arrested and cuffed, for a traffic violation. By law, the jurors do not know about this defendant's previous conviction for assault.

Summing up, Kelly asks: If the troopers meant to rough up the defendant, why not punch him? Kick him? Why just hold him until they put on the cuffs?

In his own summary, the defense attorney notes that the two officers woke up his client, who was befuddled. He says the troopers were shorthanded that day. Their cruiser became stuck in the snow. Surely, he

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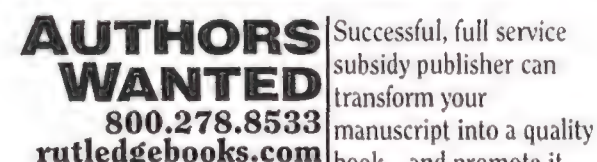
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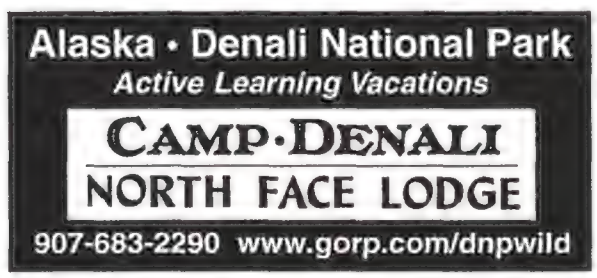


hypothesizes, they were annoyed? Ready to take out their frustrations? His client, he notes, admitted possessing marijuana. Would this man lie? Could he possibly think he could stop two large, strong troopers from arresting him?

Marijuana possession—guilty. Resisting arrest? The jury is hung.

CALENDAR CALL

TODAY—CALENDAR CALL—Judge Cheever sets dates for choosing juries. Or, by prearrangement with the prosecutors, the defendants plead guilty.

In a rare pensive moment, Trono slows his pace during one of his standard 12- to 14-hour days.

A furloughed burglar who filched a state long-distance access number, running up $11,000 telephoning sex hot lines. "Guilty, Your Honor."

A young man. Held up a Pizza Hut employee with a pellet gun as she deposited receipts. "Guilty."

Now it is Vince's turn. He has grown a Three Musketeers-style mustache and beard, and longer hair, a mellower look. Anne Whitten is away. Deputy State's Attorney Stephanie Ilberg is summarizing the case for the court. She reads Vince's affidavit admission to slapping his ex-girlfriend. "With your open hand?" the judge asks.

"May I object?" Vince's ex-girlfriend has bolted to her feet. "It wasn't just slapping—I was kicked in the head! Several times!"

Judge Cheever smiles benignly. "We're not supposed to get help from the audience, but there was help from the audience—so, do you agree with what she says?"

"I do," Vince says.

Simple assault, domestic? "Guilty."

Three counts of violating release conditions? "Guilty."

Vince says he agrees to the prosecutors' "offer": complete an intensive substance-abuse program and an intensive domestic-abuse program.

His former girlfriend walks out of the courtroom. Vince follows. His expression is inscrutable.

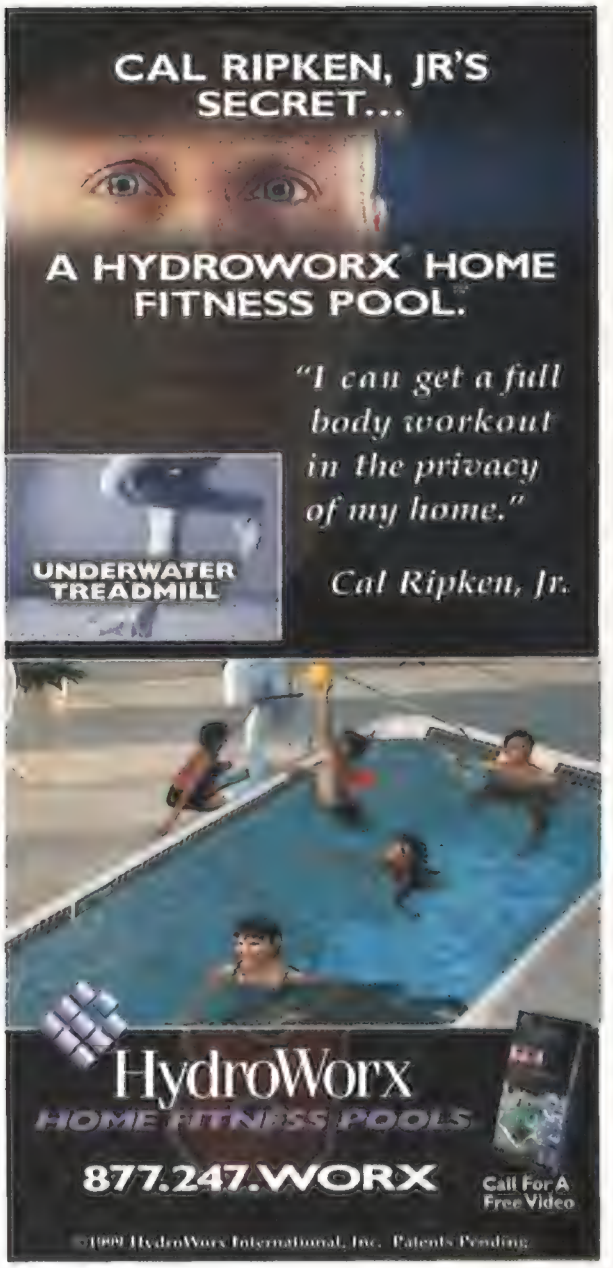
"Next case," the judge says.

AFTERMATH

CORRECTIONS OFFICIALS RULED VINCE *unsuitable for the substance-abuse and domestic-abuse programs, believing he lacked commitment. He was sentenced to 0 to 3 years in prison. Because of prison crowding, however, he was furloughed and allowed to enter less rigorous abuse programs. If he fails, he will serve his term.*

"Between the time Vince was charged and his final sentencing, we've picked up about 400 new cases," says Terry Trono. "It's like the NBA—maybe you had a bad game, but you have another game tonight and another tomorrow." He gazes out his window, at the red-brick downtown, musing. "There isn't much time to dwell on the outcomes," he says. "You get over it, and get on."

Writing this article, Richard and Joyce Wolkomir discovered how complex administering justice can be. Carolyne D. Landon has worked as a courtroom artist for television and newspapers.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BOOK REVIEWS

Mind of the Raven

Bernd Heinrich

Cliff Street Books/HarperCollins, $25

BERND HEINRICH dedicates his most recent book to "Matt, Munster, Goliath, Whitefeather, Fuzz, Houdi, and Hook," his favorite ravens. Heinrich, an internationally known biologist, also snapped a photograph for *Mind of the Raven*'s preface, showing his infant son, Eliot, snoozing in egalitarian proximity to six raven hatchlings. It is captioned: "My last batch of youngsters, including Red, Blue, Yellow, White, Orange, Green, and Eliot." By the final chapter, we are unsurprised when Heinrich describes the captive ravens that he studies not as his "subjects" but as "interesting friends."

Heinrich is analytically objective in his research, the quintessential scientist. But his experiments can be as improvisational as jazz. Once, the faint rustle of his trousers in a blind sent feeding ravens flapping away in terror, leaving the carcass to their much smaller blue jay cousins. "Just for a test," writes Heinrich, "I loudly whistled 'Oh, Susanna' and athletically jumped around in the blind." The blue jays—unlike the sissy ravens—ignored him.

In November 1997, this magazine reported on Heinrich's unusual upbringing (raised in a German forest, later on a Maine farm), his studies of

bumblebees and insect thermodynamics, and his abrupt mid-career switch. "I have lived and breathed ravens since a date I will remember: October 29, 1984," Heinrich writes. That was when he noticed a raven—ordinarily solitary—yelling to attract other ravens to share a carcass it had found. After months of spying from treetops (the possibility of falling is an ornithological occupational hazard), he discovered that youthful ravens recruit others to a carcass so they will outnumber older, mated pairs, who would otherwise drive them away. That prompted him to undertake a long-term study of raven cognition. This book reports his latest findings.

Ravens, he has concluded, are individuals, and aware. It is probably instinctive for a raven to exhibit high status by erecting feather "ears" and flaring out its leg feathers, as if wearing baggy pants, in the fashion of today's youth. But Merlin, a pet raven Heinrich observed in California, had tiffs with his owner, Duane. If Duane, upon coming home from work, neglected their greeting ceremony, Merlin would sulk. Once Heinrich saw Merlin listen raptly for two hours as Duane and another man played rock music on guitars.

We also meet Jakob, a German physician's bossy pet raven. "'The raven always wins,' the Herr Doktor told me," writes Heinrich. Heinrich knew from Jakob's mouth lining—black rather than immature pink—that he was the household's alpha, the dominant one.

"Klaus told me that whenever he gets mail, Jakob demands his fair portion of it," says Heinrich, adding that it is Jakob's pleasure to shred junk mail into confetti. Jakob also insists on being given, for his destructive pleasure, cardboard boxes and mail-order catalogs. Finishing them off, Jakob gives Heinrich a mighty peck on the thigh. "I was told he wanted the ballpoint pen with which I was taking notes," he reports, informing

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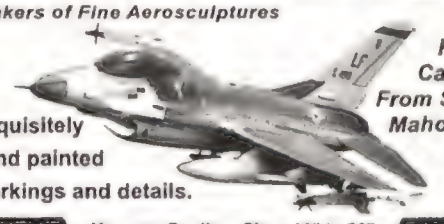

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us that he quickly surrendered the pen.

Heinrich theorizes that ravens co-evolved with wolves, and with early human hunters. To survive among such dangerous, wily predators, they had to become intelligent, too. Their keen curiosity evolved as a way to find food. It explains, Heinrich says, why ravens are so attracted to foreign objects such as baubles.

Heinrich has determined that ravens crave potato chips, fear ostrich eggs, befriend some ravens and detest others, and fall in love. He has found that ravens enjoy puckishly pulling the tails of hawks, as well as engaging in such games as hanging by one foot, shredding a beer can, stuffing tennis balls into tubes, "king of the bathtub," and drop-the-rock-on-the-dog.

Testing how his tame ravens identify people, Heinrich discovered they flew off in fear when he wore a hideous Halloween mask. If he wore familiar clothes, however, they did not mind if he approached them "faceless," a knitted green stocking cap pulled down to his chin. "On the other hand," he writes, "when I came dressed up in a bear suit they were quite alarmed, especially when I did the 'bear walk' on all fours." He tried exchanging clothes with a neighbor lady, with mixed results. A black mask and wig spooked them. Crossing his eyes and rolling them up troubled the ravens not at all. Dark sunglasses were OK. So was limping. But they definitely feared hopping on one leg. How about a kimono? He writes: "After my thirteenth approach in the kimono, they again allowed me to get next to them."

What can you make of a bird that dares to pull the tails of wild wolves, yet flees in terror from a pile of Cheerios? Heinrich says: "I have come to touch the world and the travails of a totally different yet kindred being that makes me feel less alone."

Richard Wolkomir, a frequent contributor, is based in Vermont.

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THE LAST PAGE

For a Bedtime Reader, Not Any Book Will Do

BY MARY AUGUSTA RODGERS

SEVERAL YEARS AGO, I STARTED taking a book to bed every night. It was only a matter of time before I couldn't go to sleep without one. But I discovered early on that not any old book will do.

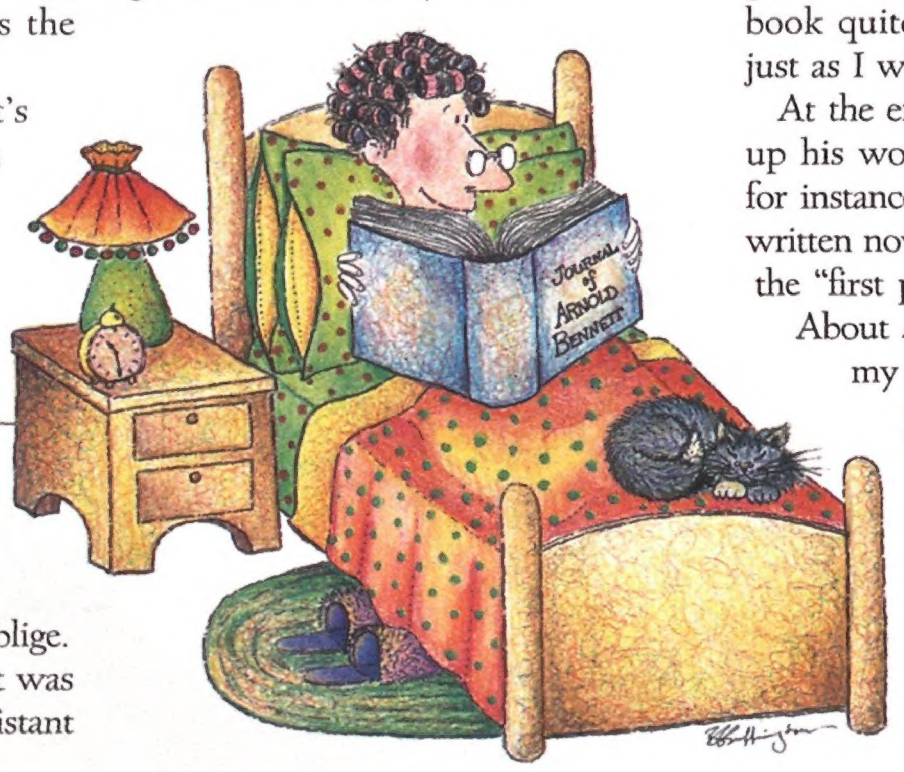
Bad and boring books are out, obviously, as well as opinionated tomes with irritating attitudes. Why go to bed with a book you don't like? You can stick with your favorite authors, of course, but even there you must pick and choose. Charles Dickens is too dense for bedtime reading. John Updike is too demanding, and Raymond Carver too sad.

At first, I was shamelessly promiscuous, picking up a book here, a book there. But after a few one-night stands with Jay McInerney and David Foster Wallace, not to mention a brief fling with John Grisham, I began to yearn for stability and commitment. I wanted a book I could depend on, one that would last. I finally found it at home, just waiting to be discovered in a back-hall bookcase. It was the *Journal of Arnold Bennett*.

Exciting? Of course not. It's easy, episodic, entertaining, rich in detail; a book that can be picked up or put down at any point. Margaret Drabble, who wrote a biography of Bennett, described him as someone who would be an ideal friend, and reading his journal, you feel that. You *like* him, you enjoy his company. And the journal (1,030 pages in its abridged version) is always there, ready to oblige.

It begins in 1896 when Bennett was a young man in London, an assistant editor with literary ambitions, and ends in 1928, three years before his death, when he was one of the most successful authors of his time. Work is a theme that runs throughout. In 1896, he recorded a conversation with a man who wondered whether he or Bennett was the more energetic. "I get up at six, go out for a walk. . . . " His program continued, alternating work and exercise, until 11 P.M. "Well," Bennett said, "that's very good indeed. How long have you been doing that?" "Oh!" the other man said. "I'm going to start in the morning!"

And this, in 1928. "Terrific day. The best I have done for years. Nearly 5000 words. I dined at the Savoy. The millionaire owner of a number of newspapers came up to me. . . . He said he wanted some really good stuff for newspaper X. I said I had too much to do. He said he worked harder than I did. I said: 'You don't!' 'Don't?' said he. 'Don't,' said I. . . . I gazed at him. His eye fell."



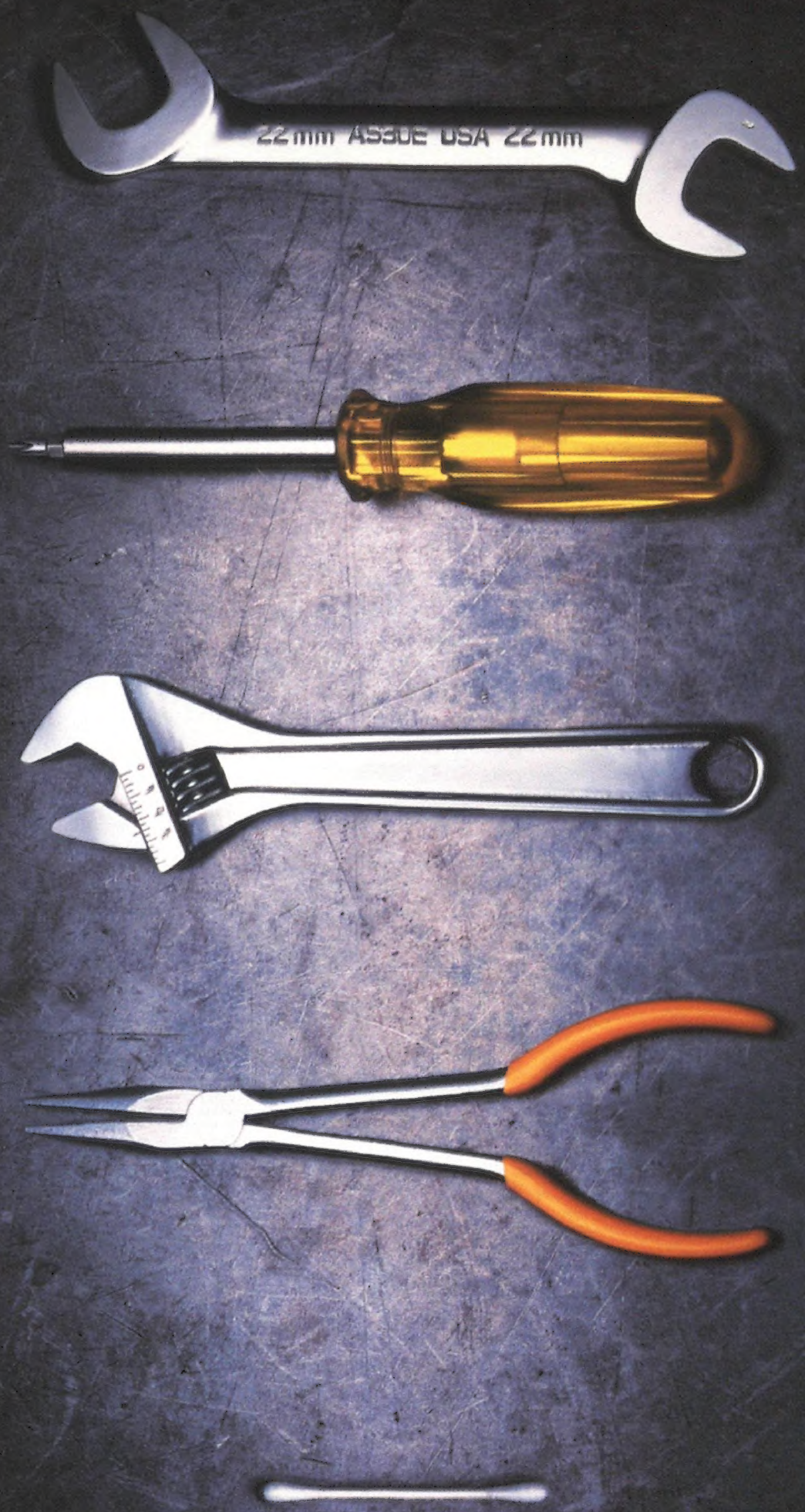
Bennett writes about travel, books, literary life, good times and bad, friends unknown and famous. He describes the fat woman he saw at a restaurant, who was the inspiration for his masterpiece, *The Old Wives' Tale*. He explains the inner workings of luxury hotels, ocean liners and play production. There is no shortage of wonderful little moments. Like the one in 1917, when Bennett met, at a dinner party, "the ultra-blonde Danish dancer Karina and her husband Captain Janssen. . . . Karina ran over Janssen in her auto and broke both his legs, and then married him. He looks after Karina so completely that he even cuts out leather for her shoes. She is very pretty and agreeable. I sat next to her and enjoyed it."

Bennett was himself a bedtime reader. An entry dated May 23, 1926, on Dreiser's *An American Tragedy*: "The mere writing is simply bloody-careless, clumsy, terrible. But there is power, and he holds you. . . . The book quite woke me up last night, just as I was going off to sleep."

At the end of many a year he adds up his work. On December 31, 1907, for instance, the list included two co-written novels, seven short stories and the "first part of *The Old Wives' Tale*. About 46 newspaper articles. And my journal. Also my play, *Cupid and Common Sense*, and scenario of a new humorous novel. . . . Grand total: 375,000 words."

Just reading such a list produces a warm feeling of gentle weariness. Good night, Arnold.

BETH BUFFINGTON



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